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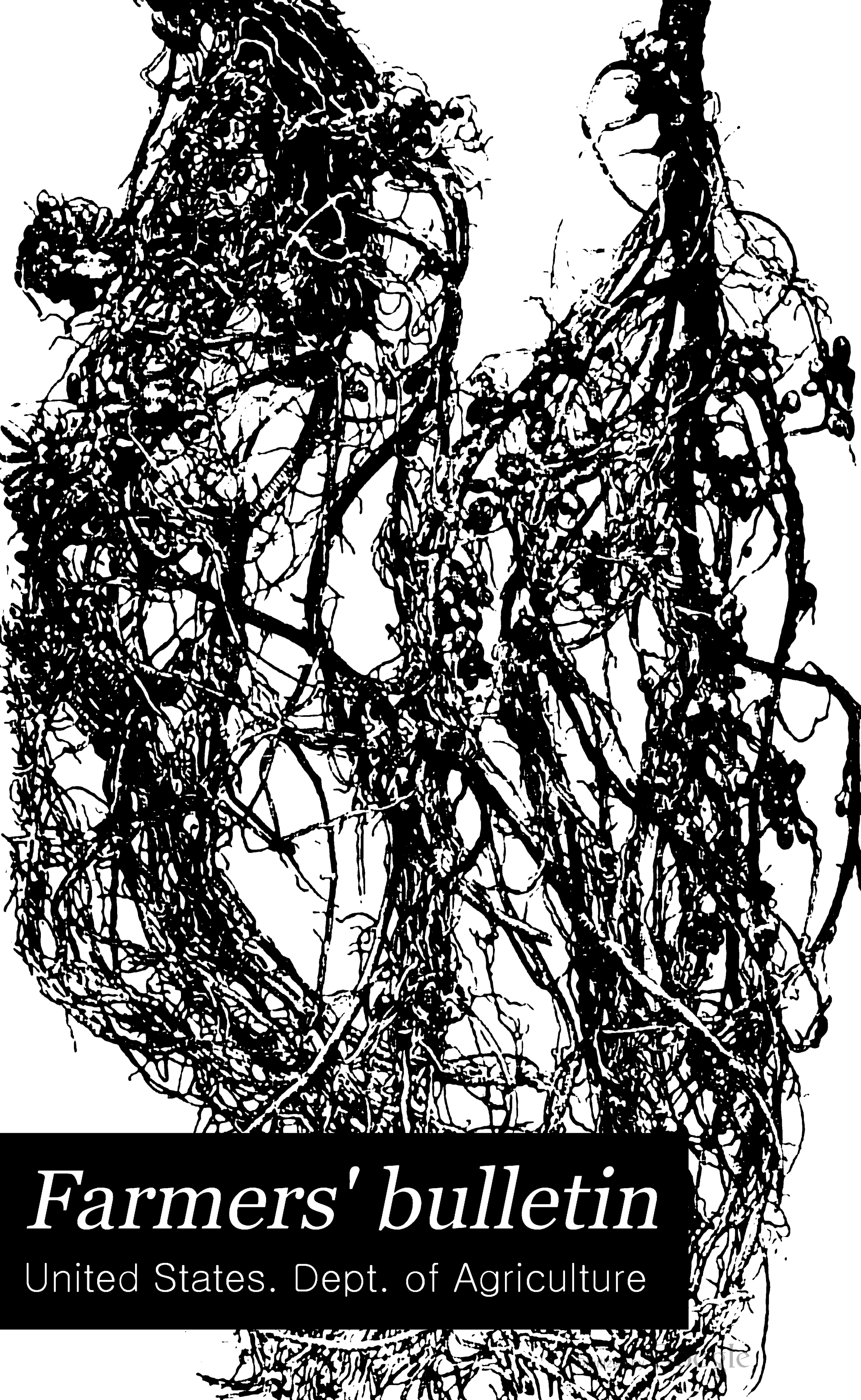

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 526.

MUTTON AND ITS VALUE IN THE DIET.

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MUTTON AND ITS VALUE IN THE DIET.

INTRODUCTION.

Mutton has from early times been a popular food both in the Orient and among western nations. The ease with which the sheep is raised and the fact that its flesh is not, like some other meats, excluded on religious grounds from the dietary of any large group of people, combine with its palatability to bring it into widespread favor. The terms "lamb" and "mutton" are somewhat loosely used to designate the meat obtained from the younger and older animals. In some localities mutton is used to apply to the flesh of all but young lambs; in others its use is limited to the flesh of full-grown sheep. The latter is perhaps the commonest usage in the United States.

The preference for lamb or for mutton, like the use of the terms, varies with the locality. Of late years a preference for lamb to older mutton has been noticeable, particularly in the United States. In England, on the other hand, mutton has always been more commonly used. The popularity of one or the other will probably always be determined by taste, fashion, or market conditions, for both are palatable and nutritious foods.[1]

The general belief that mutton and lamb are wholesome has been strengthened recently by such work as that of the United States Department of Agriculture, whose reports of meat inspection show that it has been necessary to reject relatively few mutton carcasses as unfit for food, and that the sheep is particularly free from diseases which render meat undesirable.

COMPOSITION AND NUTRITIVE VALUE.

The term "mutton" is here used to apply to the flesh of a sheep one year or more old. Such meat differs in composition from the flesh of a lamb very much as meat of any other mature animal differs from that of a young animal of the same kind, as beef differs from veal, for example, or fowl from chicken, i. e., it has, in general, a smaller percentage of water and larger percentages of fat, protein, and extractives or flavoring substances. Pound for pound, mutton has a larger amount of tissue-forming substances and a higher energy value than lamb.

So far as nutritive value is concerned, mutton is usually classed with beef. Analyses reported in an earlier bulletin of this series[2] show that they have nearly the same composition. The percentage of waste differs very slightly in the two, being on the average a little less than 20 per cent in each. In the edible portion the percentage of protein is practically the same; it averages about 18 per cent in the beef and 16 per cent in the mutton. It is only when the fat is considered that any considerable difference is noted. This averages about 20 per cent of the edible portion in medium fat beef and a little over 30 per cent in the corresponding kind of mutton. As might be expected, water is correspondingly low in the mutton and high in the beef, being about six-tenths, or 60 per cent, of the total in the beef and about five-tenths, or 50 per cent, of the total in the mutton. Because of the larger amount of fat, the fuel or energy value is greater in mutton than in beef, being usually stated as 1,500 calories per pound, while that of beef is given as about 1,145 calories. The fact should be kept in mind, however, that these figures refer to the average of many samples of the two kinds of meat. The variations in different samples of either meat are wider than the differences between these average values, and for this reason the custom of classing beef and mutton together when their nutritive values are concerned may be considered fair.

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[1] The structure, composition, and general qualities of different kinds and cuts of meat are considered in an earlier publication. (U. S. Dept. Agr., Farmers' Bul. 34, Meats: Composition and Cooking.) The value of meat as food, ways of reducing expense in the use of meat, methods of meat cookery, directions for utilizing cheaper cuts of meat in palatable dishes, and other like topics, are discussed in a similar publication. (Farmers' Bul. 391, Economical Use of Meat in the Home.)

[2] U. S. Dept. Agr., Farmers' Bul. 34.

DIGESTIBILITY OF MUTTON.

Mutton and lamb are commonly believed to digest readily without causing disturbance, and both experience and the results of scientific investigation seem to bear out this belief. To this may be ascribed the common use of mutton and lamb in invalid dietetics, as well as in the daily fare.

The question of the thoroughness of digestion of meat has been studied in connection with the nutrition investigations of this office,[1] which reported a number of experiments made for the purpose of determining the effect of different methods of cooking upon the ease and thoroughness with which various kinds and cuts of meat are digested. There was nothing in the results of the experiments to indicate that any one variety of meat or any one cut of meat has any very large advantage over others in this respect. Meats as a whole rank as very digestible foods, 97 per cent of the meat protein and 95 per cent of the fat being retained in the body, while 87 per cent of the energy of the meat is available for body uses. The figures for mutton may, however, prove interesting here, though the results differ little from those obtained with other meats. Five cuts of mutton, i. e., the shoulder, flank, leg, loin, and ribs, were all prepared in the same way, that is, by being boiled for three hours in water. In most cases several samples of the same cut were tested. After being cooked the various kinds were digested artificially. The results showed that at the end of one hour 78 per cent on an average of these cuts had been digested. The amount of digested material gradually increased until, at the end of 24 hours, less than 5 per cent of any one remained undigested. In the case of the leg the undigested portion of every sample was less than 2 per cent.

Experiments in natural digestion were also made. The subjects were men in normal health and the experimental ration was a simple mixed diet which included roast mutton. The results showed that over 99 per cent of the protein and over 98 per cent of the fat of the mutton were digested—figures which were practically identical with those obtained with roast beef. In other words, mutton, like beef, was almost completely assimilated.

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[1] U. S. Dept. Agr., Office Expt. Stas. Bul. 193.

RELATIVE ECONOMY IN THE USE OF MUTTON.

While mutton and beef do not differ materially in percentage composition or digestibility, mutton has an advantage in that it is capable of somewhat more economical use. The mutton carcass, unlike the beef carcass, is of such size that a quarter or a half, either of which supplies a variety of cuts, can be conveniently utilized in a household of moderate size with ordinary refrigerating facilities, and the price per pound is commonly less when the meat is bought in this way. There is a certain advantage, too, in the fact that the leg, which has the smallest percentage of waste of any of the cuts of mutton, is of suitable size for family use, for a piece of meat which has not been cut up keeps better than one which has been cut. On the other hand, the rather general belief, which, however, seems unfounded, that all kinds of mutton fat are unsuitable for culinary purposes, has tended somewhat to an uneconomical use of this meat. This subject receives further treatment in a later paragraph. (See p. 6.)

THE FLAVOR OF MUTTON.

The sex, age, and feeding of the animal are all factors which help to determine the natural flavor of mutton. It is said by experts, too, that dressed mutton is peculiarly liable to absorb odors and to have its own flavor modified by the flavor of other substances with which it comes in contact. For this reason, careful and quick slaughtering and dressing and good facilities for refrigerating are considered even more essential in the satisfactory preparation of mutton for market than in the case of beef or pork. Since methods of feeding are being investigated and standardized, and all the processes of handling and storage are being rapidly perfected, there is reason to look for a continual improvement in the quality of mutton found upon the market and a corresponding increase in its popularity as a food material.

The characteristic flavor and odor of mutton are said to have their origin in the fat. Lewkowitsch, an authority upon the chemistry of fats, quotes an early investigator as ascribing the odor to the presence of "hircinic acid," but this, he states, was later shown to be merely a mixture of well-known volatile fatty acids. If the characteristic mutton flavor is due to volatile fatty acids, we can understand why it is lessened by cooking with water, since such acids are volatile in steam. Cooking the fat with a little vinegar or stronger acids seems to lessen the characteristic flavor somewhat, though perhaps the effect is only to mask the mutton flavor by that of the acid. If a little vinegar or lemon juice is placed in the water in which mutton is boiled or stewed, a flavor is obtained which is different from mutton cooked without the acid, and by many considered very agreeable.

In some countries it is the custom to prepare mutton by soaking it in highly spiced vinegar and water for a day or longer, and then to roast or boil it, and serve it with a sour sauce made usually with sour cream. (See p. 21.) As vinegar is a preservative, we may imagine that this method, like that of corning meat, was first employed as a means of preservation. For such a reason, we, with our improved refrigerating processes, would seldom need to make use of it. The fact should not be overlooked, however, that during the time when this mode of preparation was frequently necessary, the dish was perfected and made appetizing. Besides being of historical interest, therefore, it may have a practical value, and those who have limited facilities for keeping food, or who for any reason seek variety in their diet, may be glad to know of it.

Whatever the reason, the habit of using acids or acid fruits and vegetables in the preparation of mutton seems to be very widespread, particularly in foreign countries or where foreign methods prevail. Creole cookbooks recommend that, in addition to the sour sauce which almost invariably accompanies the meat, a few drops of lemon juice be added to each slice of boiled mutton before it is served. In Turkey, a favorite dish is prepared by cooking chopped mutton and rice in grape leaves which are slightly acid. In some countries, quinces or sour apples are cooked with mutton. In the United States, the addition of currant jelly to the gravy of roast mutton is very common, and capers or the liquor in which they have been bottled, chopped pickles, vinegar, lemon juice, and tomato juice are often used for the same purpose. Sour apples cooked under roast mutton have been found to impart an agreeable flavor to the gravy.

THE FAT OF MUTTON AND ITS CHARACTERISTICS.

Fats from various sources, animal and vegetable, differ in hardness and in their melting and solidifying points, as well as in other physical characteristics. The melting point of mutton tallow, for example, is usually given as between 111° and 122° F.; while that of the corresponding beef fat, usually known as beef suet or beef tallow, is given as between 107° and 120° F.; and the corresponding pork fat as between 97° and 115° F. Not only do fats from different animals and plants differ in these particulars, but fats from different parts of the same animal differ also. In this laboratory, the melting point of a sample of mutton kidney fat was found to be 122° F.; that of fat from the "covering" of the leg, 114° F.; that of fat from the lean portion of the leg, which was obtained by boiling the meat and allowing the fat to rise, 105° F.; and that of a mixture of fat from the "covering" of the leg and from the interior of the lean portion of it, which was obtained from the liquid in which a leg of mutton was boiled, 107° F. It is evident from these figures that fats taken from different parts of the mutton carcass can not be classed indiscriminately when their uses and the precautions necessary in handling them are under consideration, any more than fats from different animals can be so classed. Therefore the statement frequently made in books on cookery, that fat which "tries out" from mutton is too hard to be useful for any purpose except soap making, obviously needs qualification. As a matter of fact, the fat from the leg was found in this laboratory to be suitable for many culinary purposes. It was used satisfactorily for sautéing (frying in a small amount of fat) and also in the preparation of vegetables. Since this fat would seldom be available in large quantities in the household, it was not thought necessary to experiment with it for deep fat frying.

A hard fat is very much softened if a little soft fat is mixed with it. Since the kidney fat is too hard for ordinary culinary purposes, experiments were made in mixing it with other softer fats. For this purpose, vegetable oils were used and also lard and beef fat. When economy, as well as flavor, is taken into consideration, the best results may be said to have been obtained from the mixture of two parts of mutton suet with one of lard. This mixture has a melting point appreciably lower than that of the mutton suet alone, and it was used satisfactorily for deep fat frying, for "shortening" foods with distinctive flavor, and for many other purposes. It gave fair results even in the preparation of baking-powder biscuits.

The Flavor of Mutton Fat—Savory Fat.

In the preceding pages, only the question of the hardness of mutton fats as related to their culinary uses has been considered. Objection is, however, sometimes made to the use of this fat for such purposes because of its peculiar or, as it is often described, its "muttony" flavor, which many persons do not like, though others consider it palatable. The possible nature of the flavoring substance has been spoken of elsewhere. (See p. 7.) It would make for economy if mutton fat were more commonly used in the kitchen. For this reason, tests were made of different ways of modifying the flavor so that the mutton fat might be more generally used in cooking. The most satisfactory method found was to mix some leaf lard with the suet and render with milk. The suet and leaf lard mixture was finely divided by passing it through a meat grinder, and was heated in a double boiler with about one-half of its weight of whole milk. The fat was quickly released from the tissues, and, when allowed to cool, formed a cake on the surface of the liquid, which was easily removed. Mutton suet and leaf lard, fresh and of good quality, "tried out" in this way, possessed little, if any, of the characteristic mutton odor and flavor. The best results were obtained with a mixture of two parts of mutton suet and one of leaf lard, finely ground, rendered with whole milk in proportion of ½ pint to 2 pounds of the mixed mutton and lard. This fat had an exceptionally good odor and flavor, which it retained when kept for weeks in an ordinary refrigerator. It was also of good color and texture, being softer than the mutton fat alone, owing to the milk fat and lard which it contained. If such fats are rendered in an open kettle, a moderate heat is desirable, since they "burn on" very readily. Rendering in a double boiler is much more convenient. In numerous tests, such fat proved satisfactory either alone or with a little butter for use in cooking vegetables and for other purposes.

Another way of utilizing mutton fat for frying and other culinary purposes, is in the form of savory fat, similar to that made from beef drippings and other fats. Such savory fat may be easily prepared. For each pound of the carefully rendered mutton fat, allow an onion, a sour apple, and a teaspoon of ground thyme or mixed herbs tied up in a small piece of cloth. Cook these in the fat, at a low temperature in the oven or on top of the stove, until the onion and apple are thoroughly browned. Then strain off the fat, which will be found well seasoned and may be used in place of butter or other savory fat for seasoning or for warming of potatoes, cooking vegetables, and in other ways. Winter or Hubbard squash cooked in the mutton fat until it is brown was also found in this laboratory to impart a savory flavor. The savoriness produced by the use of fruits and vegetables in this way seems to be due to the solution in the fat of specific flavoring bodies present in the fruits, vegetables, or herbs, and to the fat taking up some of the caramelized carbohydrate formed when the fruit or vegetable browns.

The fat which may be removed from mutton broth or soup is useful in many similar ways in cookery, as it has taken up flavor from the vegetables of the soup. After the soup has cooled, remove the fat, melt it, and strain through a cloth. Some of the ways of using savory fat are noted elsewhere in this bulletin. (See p. 16.)

The Solidifying Points of Mutton Fats.

Fats which have high melting points have also high solidifying points, and those which have low melting points have low solidifying points. Fats which harden at about blood heat are not commonly liked for culinary and table purposes, as they harden when eaten and make the lips and mouth feel "furry." This should be kept in mind, particularly in the serving of mutton. In this laboratory, it was found that mutton tallow, which melted at 122° F., could be cooled down to 93° F. before it again became solid, that is, to several degrees below body temperature (98.4° F.); that fat from the "covering" of the leg, which had a melting point of 114° F., had a solidifying point of 89° F.; that fat from the lean portion of the leg, which had a melting point of 105° F., had a solidifying point of 77° F.; and that a mixture of fats from the covering and the lean portion of the leg melted at 107° F. and solidified at 82° F. The difference between the solidifying points of the various fats explains the fact familiar to all housekeepers—that one mutton fat will remain liquid on a warm platter when another will become solid. The great difference between the melting point and the solidifying point of the same fat explains why it is that when the fats of mutton are once liquefied, they can, with comparative ease, be kept from again solidifying. If everything connected with the serving of mutton, particularly of those cuts which are likely to include kidney fat, is kept very hot (and, fortunately, the materials out of which serving dishes are made, china and earthenware and metal, retain heat for a long time) there will be little danger of the fat hardening during the period of an ordinary meal.

Use of Mutton Fat for Gravies.

The fact that some mutton fats solidify easily makes it necessary to take special precautions in the preparation of made gravies, i. e., those that are thickened with flour, for if the fat is intimately associated with the flour its hardening is not so noticeable. Of the two methods of making gravy commonly employed—that of thickening a liquid containing fat with a mixture of flour and water, and that of heating flour in the fat and then adding the liquid—the latter is to be preferred in the case of mutton. It should be added, however, that the argument for this method is based chiefly on greater palatability, and the fact should not be overlooked that some persons consider gravies so made to be unwholesome even when the fat has not been heated sufficiently to be decomposed, a belief which apparently has not been tested in the laboratory.

In order to bring together the various ways of using mutton fat into the preparation of one dish, the following experiment was made: In the making of mutton croquettes, mutton fat was used in three ways—in the thick white sauce with which the chopped meat was mixed; for frying; and in tomato sauce, which was served with the croquettes. Except for the frying, fat from the leg was used; for frying, rendered mutton suet was used. Pains were taken to serve the croquettes hot, and the results were pronounced satisfactory by those who were asked to pass judgment upon the dish.

CARE OF MUTTON IN THE HOME.

Because of the facility with which mutton absorbs odors and flavors, special care should be taken of it in the home. When it comes into the house, it should be wiped thoroughly with a damp cloth, and all portions that have the slightest unpleasant odor about them should be cut off. Such portions are most likely to be found where the layer of meat is thin as, for example, on the lower end of the leg, on the flank, or on the ribs. When a large piece of mutton is bought, these facts should be kept in mind in determining which parts should be used first. It is well, for example, to remove the flank end of the loin and part of the rib bones first, and use them for soups or stews. The removal of the membrane and the red skin from the surface of the meat before it is cooked is also desirable. In roasting mutton, many housekeepers believe that it is well to keep the meat well up from the pan by means of a rack, for if this is not done, the fat of the meat is likely to become scorched and to affect the flavor of the meat itself.

CUTS OF MUTTON.

For the wholesale trade a carcass of mutton is usually cut into two pieces of almost equal weight. The line of cutting is between the first and second ribs. The back half or saddle includes leg and loin, the former being about two-thirds and the latter one-third of the weight. Of the front half the rack or rib constitutes two-fifths and the breast and shoulder (including the neck and foreleg) about three-fifths of the weight. These two saddles when separated lengthwise make the fore and hind quarters—cuts commonly bought for home use. Besides these, the kidney, heart, tongue, and brains are often used for food. The head is often sold whole, and the feet are used for food in some places.

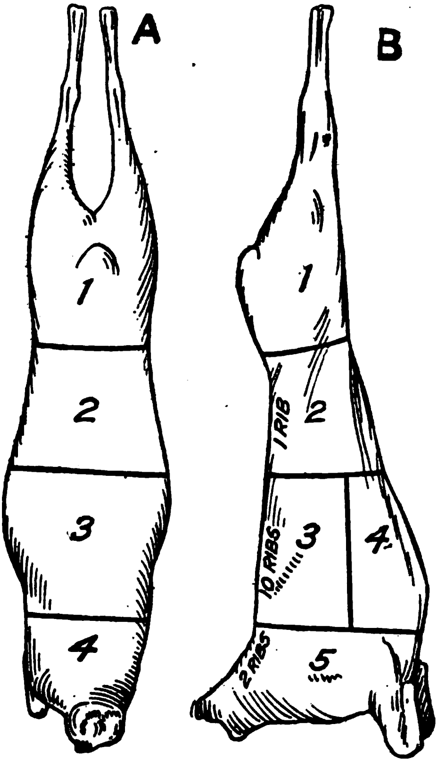

FIG. 1.—Mutton and lamb cuts: A, on the whole carcass; B, on the side.

The method of cutting meats varies somewhat in different localities. Fig. 1 is based on data reported in a bulletin[1] of the Illinois Experiment Station, and shows the location of the larger cuts on the whole carcass (A) and on the side (B). Such cuts as chops would be made by further subdividing the cuts indicated; for instance, the rib cuts would be cut into rib chops.

In considering the uses of various cuts of mutton the anatomy of the animal should be noted and also the amount of exercise which the different parts have received during life, for muscular activity tends to make the flesh tough and at the same time is thought to increase the amount of extractives or flavoring material. Meat taken from a part of the animal, therefore, which has been subjected to much muscular action is likely to need longer cooking than that taken from portions which have been little used. Such meat, however, is because of its abundant supply of extractives, even more suitable than the tenderer portions for making full flavored soups, broths, and stews.

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[1] Illinois Expt. Sta. Bul. 147.

In general it may be said that the tenderest portion of the flesh of the sheep, as of other animals, is that which lies under the backbone. This part, which is known as the tenderloin, is found partly in the hind quarter and partly in the fore quarter. It constitutes the greater part of the edible portion of the loin and an even greater percentage of the edible portion of the rib. Except for the rib, the fore quarter is less tender than the hind quarter, for its muscles have been more used.

The Hind Quarter—The Leg and Loin.

The hind quarter contains a smaller percentage of bone, besides being, as noted above, more tender on the average than the fore quarter. For these reasons it brings a higher average price per pound in spite of the fact that the rib is usually higher priced than any cut from the hind quarter.

The leg contains the smallest percentage of waste of all the principal cuts of mutton. It is often roasted, but a much more common mode of preparation is by boiling. Part of the thicker portion of the leg is often cut off in the form of steaks. When the leg is thus reduced in size, it is better to steam than to boil the remaining portion, for by the former process more of the juice is retained. A part of the leg is more convenient for roasting than the whole.

The loin is either used whole or is cut into chops. From an ordinary loin 8 to 10 chops 1 inch thick may be cut. If an attempt is made to cut a larger number, part of the hip bone is likely to be included. The true loin contains only the small bones of the spine. A saddle of mutton, as the term is used in cookery, consists of the two sides of the loin cut off in one piece. A very thick chop from the loin is called an English chop.

The loin includes, besides the tenderloin, a small amount of comparatively tough meat from the flank. Since the percentage of this tough meat is small, this cut is suitable for being cooked by the quicker processes, i. e., by roasting, broiling, panbroiling, and frying. Sometimes the flank is rolled around the tenderloin and skewered in order to make a more shapely piece of meat.

The Fore Quarter—The Rib, Shoulder, and Breast.

While the fore quarter has the disavantage over the hind quarter of having a larger percentage of bone and being tougher, it has the very great advantage of being more abundantly supplied with extractives or flavoring substances. With the exception of the rib, therefore, it is especially suitable for the preparation of broths, soups, stews, or fricassees. The meat of the neck is so tough and the percentage of bone is so great that it is seldom used in this country except for broths, for which its fine flavor and richness in extractives makes it particularly suitable. In other countries cutlets are often taken from the neck. Such use demands special care in getting the meat into shape after the bone has been removed, but the fine flavor of the meat is likely to make this extra work seem worth while.

The rib contains, besides the tenderloin, a small amount of tougher meat lying parallel with the bone. This is sometimes trimmed away to make what is known as the French chop. The percentage of bone in the rib is greater than that in the loin—a point which must be taken into consideration in estimating the comparative values of the cuts. The rib is somewhat less convenient to use, too, than the loin, for, because of the position of the bones, there is less choice about the thickness of the chops. The rib, being very tender, may be prepared by the same quick processes as the loin, i. e., by roasting, broiling, panbroiling, and deep-fat frying. Since the chops are usually thinner than loin chops, they are especially suitable for being egged, crumbed, and fried in deep fat, for by this process little juice is lost.

The breast may be rolled and roasted, but it will usually be found desirable to cook it for a short time in water first. The shoulder is roasted either whole or with the bone removed. If the bone is removed, the space should be filled with a savory dressing.

Kidneys, Liver, Heart, and Head.

The kidneys are broiled, fried, or stewed. The liver is usually braised. The heart is cooked in water after having been fried. The head may be cooked whole in a small amount of water and the meat removed from the bones and scalloped. The brains are boiled and then fried. The tongue is boiled or parboiled, after which it may be prepared in a great variety of ways.

JUDGING MUTTON.

There are a number of points which should be borne in mind when purchasing mutton for the table. The lean portion of the meat should be firm, finely grained, and of a deep red color. The fat should be well distributed. The leg should be nearly covered with a layer of fat and there should also be a thick layer over the back. This outside layer is often in the trade referred to as the "covering." The fat itself should be white, hard, brittle, and flaky. The "mottling" of the flesh with fat, which is so important a sign of good quality in beef, is considered of less importance in judging mutton.

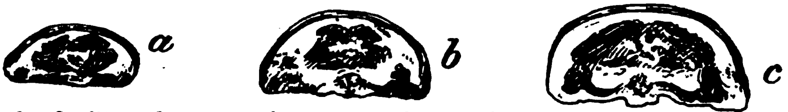

FIG. 2.—Quality and economy of mutton as related to distribution of fat and lean: *a*, fat layer around lean too small for good quality; *b*, fat and lean well distributed; *c*, fat layer too large and corresponding waste too great.

For superior quality, lean and fat should be well distributed, i. e., the lean portion should contain a fair percentage of fat in its tissue and be surrounded wholly or in part by a reasonable layer of fat. The right distribution of fat is important since it affects both flavor and quality. If the meat is too lean, it is not so palatable when cooked; if too fat, it is not economical, since the excessive quantity would remain uneaten, and when purchased in the form of an expensive roast is high in cost in comparison with similar fat which could be purchased for culinary use. Fig. 2 illustrates these points.

WASTE IN VARIOUS CUTS.

In estimating the relative values of the various cuts and the prices which should be paid for them per pound it is necessary to know the percentage of waste in each. The following figures from an earlier bulletin[1] of the department represent averages of a number of determinations: Side (including tallow), 19.3 per cent waste; side (excluding tallow), 18.1 per cent; hind quarter, 17.2 per cent; fore quarter, average 21.2 per cent; leg, 17.7 per cent; loin (which includes rib and is without kidney or kidney fat), 14.8 per cent; shoulder, 22.1 per cent; and neck, 26.4 per cent.

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[1] U. S. Dept. Agr., Office Expt. Stas. Bul. 28.

LOSSES OF WEIGHT IN COOKING MUTTON AND OTHER MEATS.

There have been reported in another bulletin of this department[1] experiments made for the purpose of determining the effect of cooking upon the composition of various kinds and cuts of meat. In the course of this work, comparable cuts of mutton and beef, both taken from the leg, and with nearly the same percentage of fat, were prepared in the same way, i. e., by being boiled in water for three hours. The results showed that the nitrogenous extractives which are so valuable a part of meat broths were as high in the mutton broth as in the beef broth. On the other hand, the percentage of fat in mutton broth was noticeably higher than in the beef broth, although the meat from which the broth was made had a slightly smaller percentage of fat. This would indicate that mutton fat is removed more easily from the tissues in the process of cooking than is beef fat.

EFFECT OF HEAT UPON THE VARIOUS CONSTITUENTS OF MUTTON.

In considering the various ways of preparing mutton, the effect of heat upon its different constituents should be noted. The proteins of mutton, as of other meats, are numerous, but they fall naturally into two classes—those which are insoluble in cold water and those which are soluble. In a previous publication of this department[1] it was shown that in the case of beef the proteins soluble in water constituted about 13 per cent of the whole, and the proteins of mutton probably differ slightly in this respect from those of beef. Both the soluble and insoluble proteids are hardened by the application of heat, and a large percentage of the soluble proteins are rendered insoluble. In the publication referred to, it was stated that of the proteins of beef which had been cooked in hot water for several hours only 0.4 per cent were soluble, as compared with 13 per cent in the raw meat.

When meat is soaked in cold water, not only are the soluble proteins removed but also all of the extractives or flavoring materials and a large percentage of the mineral matter. When this water extract is heated, the proteins begin to coagulate at 52° C., or about 126° F. The process seems to be completed at about 85° C., or about 185° F. The extractives, on the other hand, are not made insoluble by heat and remain in solution even at the temperature of boiling water.

The effect of hot water during cooking, either the water naturally present in the meat or that in which meat is cooked, upon the gelatinoids of the meat, which form the chief solid constituent of its connective tissue, is to convert them into gelatin—a substance which unites with water to form a jelly. The effect, therefore, of long-continued cooking of meat, particularly in water, is to soften or destroy the connective tissue, and thus to separate the fibers of the meat from each other.

The fat, which constitutes a large percentage of the nutrients of meat, is not affected chemically in cooking except by very high temperatures, such as may be obtained in frying, broiling, and roasting. When due care is taken, the effect of cooking it is merely to release it from the tissues. The very high temperature to which fat can be brought without being changed, accounts for its usefulness in the culinary process known as "basting," which consists in repeatedly searing the surface of the meat while it is being roasted by pouring hot fat or a mixture of hot fat and water over it.

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[1] U. S. Dept. Agr., Office Expt. Stas. Bul. 162.

METHODS OF COOKING MUTTON.

In the following pages there are given a large number of recipes which have been brought together from many sources. Most of them are for standard dishes. Some of them, however, are for dishes which, though highly esteemed in other countries, are not well known in the United States, and a few are for rather complicated dishes. The insertion of these recipes for unfamiliar and elaborate dishes should not be taken to indicate that a greater value is placed upon them than upon mutton prepared by the simple methods of boiling, roasting, or broiling. They are included because tests have shown them to be palatable, and because a knowledge of many ways of preparing any given food is an easy way of securing variety in the diet. More necessary than to know how to prepare mutton in a variety of ways is to keep in mind the essential factors which contribute to its satisfactory preparation in simple ways, i. e., the careful removal of all portions having an unpleasant odor, the mastery of the art of preparing well a simple gravy, and care to keep hot such dishes as are intended to be served hot.

Even if we recognize the advantage of simple methods skillfully followed out over complicated methods, we must recognize also that if a greater number of modes of preparation were understood in this country and if a greater variety of savory sauces were used the possibilities of serving mutton in acceptable forms would be greatly increased.

That quality of mutton which makes it absorb odors and flavors easily is an advantage in cooking, for its own flavor combines easily with that of the various seasonings in cooking, and, for this reason, the meat yields itself readily to the preparation of savory dishes. The experience of cooks has, in fact, taught two general ways of cooking mutton, one of which consists in developing its own flavor by cooking it alone, and the other in uniting it with highly seasoned vegetables or other substances in such a way as to modify its flavor and to produce a new flavor by the combination. The two methods are well illustrated by recipes for boiling mutton given on pages 17 and 18. The first of these directs that it be cooked in water unseasoned by other substances than salt; the second, that such substances as herbs, onions, or garlic be rubbed into the meat and bound closely to its surface by means of a cloth before the meat is put into water.

METHODS OF MEASURING.

Many of the recipes brought together for this bulletin were very indefinite in their statement of amounts of ingredients. For this reason special attention has been given to the matter of measurements, and wherever it has been considered essential the amounts are given exactly. The measurements in all cases are level. A teaspoonful of an ingredient, for example, means enough to come up to the edge of the bowl of the spoon. Such an amount is conveniently measured by first taking up more than is needed and then pushing off any in excess by means of a knife, allowing the edge of the knife to rest on the spoon.

MAKING OF SOUPS AND BROTHS.

An object to be kept in mind in the making of broths and soups is to get as much as possible of the flavoring bodies and of the nutritive material of the meat into solution or suspension in the water. This is accomplished, first, by dividing the meat into small pieces in order to increase the surface exposed, and, second, by keeping the temperature low in order to prevent the proteids from coagulating. When the water in which the meat has been soaked is brought to the temperature of about 52° C., the dissolved proteids begin to harden and rise to the surface in the form of scum. This scum is often removed for esthetic purposes, but it should be remembered that the effect of doing this is to reduce the nutritive value of the broth. Whenever there is the slightest doubt about the quality or the freshness of the meat, however, the removal of the scum is recommended, for under these circumstances its removal seems to improve the flavor.

Practically the only nutritive material left in a broth, which has been cleared and from which the fat has been removed, is gelatin and a little mineral matter. Gelatin is usually described as a protein sparer. So far as we know at present, it does not have much value either in building or repairing tissues. However, when it is taken in the food, less protein seems to be required. The amount of gelatin present, even in the richest soup, is very small, and for invalids it is sometimes desirable to leave the albumin of the meat juice in solution in the broth. This can be done if the broth is not heated above 130° F.

Recipes for mutton broths and soups follow:

Mutton Juice and "Extract."

Mutton juice or "extract" may be prepared according to any of the ways recommended for beef juice or homemade "extract." One way is to broil a piece of the meat on both sides, and then cut it into small pieces and extract the juice, for instance, by pressing it with a lemon squeezer or between two plates with a heavy weight on top. The object of broiling has usually been said to be "to start the flow of the juice." An additional reason, however, may be found in a bulletin of this department[1] which shows that there is a much greater percentage of soluble material in meats cooked by dry methods, such as roasting, broiling, frying, and panbroiling, than in those cooked in hot water. A less concentrated extract is made by cutting the meat into small pieces and cooking it in water with the precaution mentioned above—that of keeping the water below 130 F. This is most conveniently done in a double boiler or in a glass fruit jar immersed in water.

Mutton Broth.

3 pounds mutton from the neck.
2 quarts cold water.
3 tablespoons rice or barley.
1 teaspoon salt.

Wipe the meat, remove the skin and fat, and cut the meat into small pieces. Put into the kettle with bones, and cover with the water. Heat gradually to the boiling point and season with salt and with pepper if liked. Cook slowly until the meat is tender, strain, and remove the fat. Reheat to boiling point, add the rice or barley, and cook until the rice or barley is tender. If barley is used, soak it over night in cold water.

Mutton Soup.

4 pounds mutton from the neck.
3 quarts cold water.
3 carrots.
2 turnips.
1 small cabbage or part of a larger cabbage.
1 stalk celery.
Few sprigs parsley.
1 medium-sized onion.
6 cloves.
1 sprig thyme.
1 sprig marjoram.
2 tablespoons salt.

Wipe the meat carefully, cut into small pieces, and cover with the water. Bring very slowly to the boiling point and skim. Add the vegetables cut into small pieces and other seasoning, and cook slowly for three hours. Strain, cool, and remove the fat. Serve either clear, with rice, or with the vegetables finely chopped.

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[1] U. S. Dept. Agr., Office Expt. Stas. Bul. 162.

MUTTON STEWS.

In preparing mutton for stews, several different plans may be followed. The meat may be cut into small pieces and cooked in water, or it may be first browned in fat before being cooked in water. Another way is to mince the raw meat, cook in a little fat, and then combine with vegetables. This is suitable when the vegetables used are very juicy as in Minced Mutton with Eggplant. (See p. 28.)

Curry of Mutton.

2 pounds mutton from the fore quarter.
1 onion.
1 teaspoon vinegar.
2 tablespoons flour.
1 teaspoon curry powder.
Salt.
Boiling water.

Cut off small portions of the fat and try them out. Remove the unmelted portions, and in the remainder fry the meat until it is a delicate brown. Add the onions and pour over all enough boiling water barely to cover. Cook until the meat is tender. Add the curry powder, vinegar, and salt. Remove the meat, reduce the broth to one cup, and thicken it with flour diluted with cold water. Add the meat to the gravy and reheat. Serve with rice.

Okra and Mutton Stew.

1 pound lean mutton free from bone.
2 tablespoons butter or drippings.
2 tablespoons flour.
2 onions.
2 cups tomatoes.
2 cups okra, cut into thin slices.
1½ teaspoons salt.
⅛ teaspoon pepper.
Water.

Wipe the meat and cut it into cubes. Wash the okra and cut into thin slices, dredge it and the meat with the flour, and fry them in the fat until brown. Add the other ingredients, using water enough barely to cover and cook slowly either in the oven or on top of the stove in a tightly covered dish.

Scotch Broth.

1 quart rich mutton broth free from fat.
1 carrot.
1 turnip.
2 onions.
4 stalks celery.
2 tablespoons butter or mutton fat.
2 tablespoons flour.
Salt.

The liquor in which mutton is boiled may be used in preparing this dish, but it will usually need to be boiled down. Cut the vegetables into small pieces and cook them slowly in the stock for two hours. Rub the flour and butter together and add to them a little of the hot broth. Stir until the mixture is smooth, then add it to the broth.

When no mutton stock is on hand, prepare it from 2 pounds of mutton from the fore quarter. Remove the meat from the bone and cut into small pieces and, for convenience, tie the bones in a small piece of cloth and cook in the same water in which the meat is cooked. In this case, serve the meat with the broth.

Ragout of Mutton with Farina Balls.

1½ pounds neck of mutton cut into small pieces.
1 tablespoon butter.
1 tablespoon flour.
1 onion cut into small pieces.
1 carrot cut into small pieces.
2 cups hot water.
1 teaspoon salt.
¼ teaspoon pepper.
½ bay leaf.
1 sprig parsley.
6 cloves.
1 cup fresh peas or ½ can peas.

Put the butter into a frying pan. When melted add the flour and let it brown. Then add all the other ingredients except the peas, and cook slowly for two hours. A short time before serving, add the peas.

Serve with farina balls made as follows:

1 cup farina.
1 cup milk.
¼ teaspoon salt.
⅛ teaspoon pepper.
Few drops onion juice.
Yolk 1 egg.

Cook farina and milk in the double boiler one hour. Add seasonings and well-beaten yolk. Stir well and cool. When cold, roll into balls. Dip in egg and crumbs and fry in deep fat. Rice may be used in a similar way.

Ragout of Mutton with Summer Squash.

2 pounds mutton from the shoulder or breast.
1 onion.
1 medium-sized summer squash.
1 sweet green pepper.
2 stalks celery.
4 medium-sized potatoes.
¼ teaspoon powdered thyme.
¼ teaspoon powdered marjoram.
Bit of bay leaf.
Garlic. (See below.)
Salt.

Cut the meat into small cubes and place in a deep baking dish. Cook in a hot oven until well browned. Add the onion cut into cubes, the summer squash sliced, sweet peppers and celery cut into small pieces, and the other seasonings. Sufficient flavor of garlic will be obtained by rubbing the dish with a clove of garlic or by adding a very thin slice from one of the cloves. Cover the dish and allow the vegetables to cook for an hour with the meat, without the addition of water. Then add the potatoes, cut into slices. Cover the dish again and cook for another hour.

Ragout of Mutton with Eggplant.

Follow the directions given in the above recipe, substituting an eggplant for the summer squash.

Syrian Stew.

2 cups raw mutton cut into cubes.
2 tablespoons fat.
3 tablespoons flour.
2 cups string beans.
2 onions.
2 cups tomatoes.
Salt.
Water.

Dredge the meat with the flour and brown it in the fat. Put all the ingredients in a stewpan, scraping from the frying pan all of the flour and fat, and add enough water barely to cover. Cook slowly until the meat is tender.

Haricot of Mutton.

2 tablespoons butter or drippings.
2 tablespoons chopped onions.
1½ pounds lean mutton cut into 2-inch pieces.
2 cups water.
Salt and pepper.
Lima beans.
Chopped parsley.

Fry the onions in the butter, remove the onions, add the meat, and brown; cover with water and cook until the meat is tender. Serve with a border of Lima beans, seasoned with salt, pepper, butter, and a little chopped parsley. Fresh, canned, dried, or evaporated Lima beans may be used in making this dish.

Stewed Sheep's Hearts.

2 sheep's hearts.
2 ounces fat salt pork.
2 tablespoons minced onion.
2 tablespoons flour.
¼ teaspoon pepper.
1½ pints boiling water.
Salt.

Split and wash the hearts, season them with the salt and pepper, and roll them in the flour. Try out the pork, and add the onions to the pork fat and cook them 10 minutes. At the end of that time, remove the pork and onions to a stewpan and fry the hearts in the fat. Transfer hearts to the stewpan. Rinse the frying pan with the water, which should then be poured over the hearts. Use the flour that remains after the hearts are rolled to thicken the broth. Cook the hearts in the gravy for three hours, being careful to keep the temperature just below the boiling point. At serving time, the hearts are usually sliced and the gravy poured over them.

Sheep's Tongues.

6 sheep's tongues.
2 carrots cut into small pieces.
1 pint boiling water.
1 large onion cut into small pieces.
2 slices bacon.
¼ cup capers.
3 small cucumber pickles.
Salt and pepper.

Scald and blanch the tongues, removing the skins and then throw the tongues into cold water until ready to use. Cut a slice of bacon into fine strips and lay them in the bottom of a saucepan; place over this the lamb tongues seasoned with salt and pepper, and over the tongues another layer of bacon in very fine strips. Add the minced carrots and onion; salt and pepper again to taste and let the tongues simmer for about 15 minutes, and then moisten with about a pint of boiling water or broth. Cook slowly about three hours. Then take out the tongues, place them on a hot dish, strain the sauce, reheat, and add one-fourth cup of capers and three small cucumber pickles, sliced thin. Stir well and let the sauce boil up once. Pour over the tongues and serve.

BOILING, STEAMING, AND BRAISING.

Boiling, as the term is usually used, consists in cooking in water enough to cover, and at the temperature of boiling water. The best results are obtained by using large pieces of meat because, in this case, less of the flavoring material is lost than if the meat is cut into small pieces. Recipes for boiling meat usually direct that the meat be put into boiling water, and that the temperature be again brought to the boiling point as quickly as possible and kept there for a few moments in order that the proteins on the surface of the meat may coagulate and form a crust. It has been thought that by this means a crust is formed which tends to keep in the juices of the meat. In a previous bulletin of this department,[1] however, it has been shown that experiments do not bear out this belief. Pieces of meat were put into cold water and slowly brought up to the boiling point, and similar pieces were plunged into boiling water. At the end of the given time it was found that there was no essential difference between the amount of material which had been extracted from the meat in the two cases.

For the common custom of searing the surface of the meat in hot fat before boiling it, there is more theoretical justification, for the high temperature develops new flavors and also, as we have said before, this form of cooking tends to increase the soluble materials of the meat.

Two substitutes for boiling by ordinary methods should be mentioned. One is braising, which consists in cooking in a closely covered earthenware dish in the oven; the other is cooking in a fireless cooker. The formal name of the dish used for braising is the "casserole," but any heavy dish supplied with a close-fitting cover will serve the purpose. A heavy plate may be used for the cover. The advantage of this way of cooking over ordinary boiling is that less water is necessary and the broth is, therefore, richer. The advantage of cooking in a fireless cooker is that it is not necessary to watch the meat during the process. When this method is employed in cooking a leg of mutton, 3 or 4 quarts of water should be used and the meat should be boiled for one-half hour before it is placed in the cooker, and should be cooked six hours or more afterwards.

Boiled Leg of Mutton.

After wiping the meat thoroughly with a damp cloth, cover it with water which, if haste is an object, should be hot. Cook about 15 minutes for each pound, keeping the temperature a little below the boiling point. The proper temperature will be indicated by a slight bubbling. When the meat is partly done, add the salt and water.

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[1] U. S. Dept. Agr., Office Expt. Stas. Bul. 162.

Boiled Mutton with Vegetables.

To the water in which a leg of mutton is boiled the following may be added:

2 sliced carrots.
1 sliced turnip.
2 sliced onions.
2 stalks celery.
1 bay leaf.
2 cloves.

The advantage of using these additional substances is that besides flavoring the meat and making an attractive garnish for it, they add flavor to the broth and thus improve it for use in soups or sauces.

Boiled Mutton with Sweet Herbs.

After the leg of mutton has been wiped, mix the following and spread over the surface. Wrap the meat in a cloth and fasten the cloth about the meat by means of a cord or skewers in order to hold the seasonings close to the surface:

1 clove of garlic, finely chopped.
1 finely chopped onion.
1 teaspoon powdered thyme.
1 teaspoon powdered sweet marjoram.
1 teaspoon salt.

Boiled Mutton with Oyster Sauce.

4 pounds mutton from the shoulder.
1 onion.
1 pint oysters.
Salt.

Bone the mutton and stuff with half the oysters, or make a gash in the meat near the bone and insert half the oysters and tie into shape. Half cover the meat with water and cook in a closely covered dish for 2 hours. With the remaining oysters make the following sauce:

OYSTER SAUCE.

2 tablespoons butter or mutton fat.
1 tablespoon flour.
½ pint oysters.
½ cup of the liquid in which the mutton has been boiled.

Drain the oysters and heat and strain the liquor. Wash the oysters, add them to the hot oyster liquor and cook until they are plump. Remove the oysters and keep warm while making a sauce of the butter, flour, oyster liquor, and mutton stock. Add the oysters and season with salt and pepper.

Steamed Mutton.

Small pieces of mutton may be very satisfactorily prepared by covering the surface with powdered or finely chopped seasonings, as suggested in the foregoing recipe, and steaming it, or it may be steamed without the seasonings.

Sauces for Boiled or Steamed Mutton.

CAPER SAUCE.

⅓ cup butter or mutton fat.
1½ cups hot water or mutton broth.
2 tablespoons flour.
½ teaspoon salt.
½ cup capers drained from their liquor.

Melt half the butter or all the mutton fat, add the flour, and cook thoroughly. Pour the hot water or stock on gradually. Before serving, add the remaining butter (if this is the fat used in preparing the dish) and the capers. If the gravy is made somewhat thicker than as above directed it can be spread over the surface of the meat. This covers any irregularities in the surface and is thought by some people to improve the appearance of the dish.

MOCK CAPER SAUCE.

For the capers in the above recipe, chopped sour pickles may be substituted.

PARSLEY SAUCE.

2 tablespoons butter or mutton fat.
2 tablespoons flour.
1 cup milk or mutton broth.
Salt.
Juice of ½ lemon.
1 tablespoon finely chopped parsley.

Melt the butter, add the flour, and cook for two or three minutes, stirring constantly. Add the milk and cook until the liquid is thickened. Season with salt. Just before serving add the lemon juice and parsley.

HORSE-RADISH SAUCE NO. 1.

(For cold boiled mutton.)

2 tablespoons cracker crumbs.
2 tablespoons butter or mutton fat.
¼ cup grated horse-radish root.
½ teaspoon salt.
1 cup milk.

Cook the crumbs, horse-radish, and milk 20 minutes in a double boiler. Add the remaining ingredients and serve either hot or cold.

HORSE-RADISH SAUCE NO. 2.

½ cup thick cream.
3 tablespoons grated horse-radish root.
1 tablespoon vinegar.
Salt and cayenne.

Whip the cream and add the other ingredients.

Mutton Savory Loaf.

2 pounds lean mutton free from bone.
2 pounds lean fresh pork free from bone.
1 small onion.
1 green pepper.
2 stalks celery.
1 bunch parsley.
1 cup milk.
2 eggs.
½ teaspoon each curry powder, powdered thyme, black pepper, and paprika.
1½ tablespoons salt.
1 pound bacon sliced very thin.

Remove the seeds from the pepper and put the vegetables and meat through a meat grinder, using the finest chopper for the vegetables, and chopping the meat about as fine as for Hamburg steak. Mix thoroughly all the ingredients but the bacon. Form the chopped meat mixture into a roll about 2 or 3 inches in diameter; cover the sides and ends completely with the bacon, roll in a pudding cloth or a piece of cheesecloth, and tie securely. This can be conveniently done by laying the cloth on a flat surface, and then laying the strips of bacon upon it side by side in such a way as to form a continuous layer large enough to cover the whole surface of the meat roll. Put the meat roll in the center, and bring the bacon up around the sides and ends. The cloth should be tied securely at the ends, and either pinned or sewed securely at the side. Boil for three hours in just enough water to cover, to which has been added one tablespoon of salt and one-half cup of vinegar. This may be served cold or may be cut into slices and fried. This mixture may also be either steamed in a mold or baked. If this is done, the bacon should be used to line the mold and cover the top of the mixture. If baked, it is well to add to the meat mixture a cup of bread crumbs and one-half cup more milk.

For the fresh pork in the above, either an equal amount of ham, veal, or a mixture of veal and salt pork, may be substituted. When ham or salt pork is used reduce the amount of salt.

Braised Leg of Mutton.

1 leg mutton.
½ medium-sized onion.
1 carrot.
1 turnip.
½ bay leaf.
1 sprig each thyme and parsley.
¼ cup mutton drippings or butter.
1½ teaspoons salt.
12 peppercorns.
3 cups hot water.

Have the leg of mutton boned. Wipe, stuff with the mixture described below, sew, and place in a deep pan. Cook the onion (sliced), the carrot and turnip (cut into dice), bay leaf, thyme, and parsley five minutes in the butter or mutton drippings. Add the hot water, salt, and peppercorns, and pour the mixture over the mutton. Cook slowly for three hours, with the dish covered except for the last half hour. Make a brown gravy out of the strained broth in which the meat has been cooked. (See p. 21.)

STUFFING FOR BRAISED LEG OF MUTTON.

The stuffing for the braised leg of mutton is made as follows:

1 cup cracker crumbs.
2 tablespoons melted butter.
¼ teaspoon salt.
⅛ teaspoon pepper.
½ teaspoon poultry seasoning.
¼ cup boiling water.

Oven Pot Roast.

3 pounds mutton from the shoulder.
1 cup potatoes cut into small pieces.
1 cup carrots cut into small pieces.
¼ cup sliced onion.
2 tablespoons flour.
Salt.

Put the meat into an earthenware bean pot and cover with boiling water. Place the cover on the pot and let the meat cook in a moderate oven for two hours. Add the vegetables and the salt, cover again, and cook for one hour. Reduce the liquid in which the meat and vegetables have been cooked to one cup and thicken with the flour.

Shoulder of Mutton Braised with Turnips.

6 pounds mutton from the shoulder.
1 onion.
1 carrot.
1 stalk celery.
4 cloves.
½ bay leaf.
1 quart water.
6 turnips.
Salt.

Cut the onion, carrot, and celery into small pieces and put these with the shoulder of mutton into a deep baking pan. Cover, and allow the mutton juice to permeate the vegetables and brown with them. Then add the water, cloves, and bay leaf. Cook in a moderate oven until the meat is tender, which will be about 20 minutes for each pound. One hour before serving, add the turnips, which have been peeled and parboiled.

Braised Breast of Mutton.

1 breast mutton.
Few slices bacon.
½ pint stock.
1 lemon.
1 onion.
Salt.

Line the bottom of a casserole or other earthenware baking dish with a few thin slices of bacon, lay the mutton on these, and put over it the lemon, which has been peeled and cut into slices. Cover with one or two more slices of bacon and add the stock and onion. Cover the dish. Cook slowly on the top of the stove or in the oven until the meat is tender.

Mutton Smothered in Tomatoes.

1½ pounds mutton steak.
1 cup bread crumbs.
1 small onion.
Poultry seasoning.
Salt.
1 can tomatoes, or 1 quart fresh tomatoes cut in slices.

Spread over the mutton steak a layer of bread crumbs mixed with the minced onion and other seasonings. Roll and tie into shape. Place in a casserole or other dish with a tightly-fitting cover. Pour the tomatoes over the meat and cook very slowly in the oven or on top of the stove for three or four hours. If the tomatoes do not cover the meat, add a little boiling water.

Braised Leg of Mutton with Sour Gravy.

1 leg of mutton.
2 tablespoons butter or drippings.
8 cups vinegar.
3 cups water.
½ teaspoon each of powdered thyme and marjoram.
½ dozen cloves.
1 clove of garlic.
½ cup each of celery, carrots, and onions finely chopped.
2 tablespoons chopped parsley.
1 dozen pepper corns.
½ bay leaf.
1 pint sour cream.
½ pint stock.
Salt.

Fry the celery, carrots, and onions in the fat until light brown, add the vinegar and water, and cook until the vegetables are soft. When this mixture is cool, pour over the leg of mutton, which should be fully covered and which. for this reason, should be in a dish just large enough to hold it. Allow the mutton to lie in this mixture for 24 hours. Upon removing it, drain quite dry and bake in a moderate oven for 30 minutes. Then pour the sour cream and stock around it and cook until tender, basting frequently. Reduce the liquor in which the meat has been cooked to a small volume, strain it, and pour over the meat.

ROASTED MUTTON.

The term "roasting" was originally applied to cooking before an open fire, but as now used it is usually synonymous with baking. Since meat cooked by this process is subjected to dry heat, even greater precautions must be taken to prevent the escape of juices than in boiling. The oven should be very hot until the meat is thoroughly seared; then the temperature should be reduced and the fat which drips from the meat should be frequently poured over its surface.

Roast Leg or Saddle of Mutton.

Sprinkle the meat with salt and pepper, place upon a rack in the baking pan, and dredge with flour. Bake in a hot oven, basting frequently. Allow from 10 to 15 minutes per pound, depending upon whether it is desired well done or not.

BROWN GRAVY FOR ROAST MUTTON.

In making gravy for roast mutton or any other roast meat, allow 2 level tablespoons of fat for each cup of gravy desired, pouring off any in excess of this amount. To the fat add 3 tablespoons of flour and cook thoroughly, browning it, but being very careful not to burn it. Add boiling water or broth and boil for a short time, stirring constantly. Add salt and pepper. The proportions are 2 tablespoons of fat, 3 tablespoons of flour, and 1 cup of water or stock. If the flour is not browned, only 2 level tablespoons are needed for each cup.

CURRANT-JELLY GRAVY.

A gravy flavored and made acid with currant jelly is often served with roast mutton. To each cup of brown gravy made from the fat of roast mutton add a glass of current jelly or less. As noted elsewhere (p. 27), the addition of currant jelly is specially suitable when cold mutton is to be warmed up in gravy.

MINT SAUCE AND MINT JELLY.

¼ cup finely chopped mint leaves.
1 tablespoon powdered sugar.
½ cup vinegar.
¼ teaspoon salt.

Combine the ingredients and let the mixture stand in a warm place until the flavor of the mint has penetrated the liquid.

Mint sauce, which is so generally relished with roast mutton and roast lamb, may be made from either the fresh or the dried spearmint. Mint jelly, which is also popular, can be made by stiffening mint sauce with gelatin. For this purpose one-half tablespoonful of gelatin soaked in cold water enough to cover it may be use with a cup of mint sauce made as above from freshly chopped mint leaves; or make a mint sauce by boiling together one cupful each of vinegar (not too strong) and sugar for about five minutes and adding three-fourths cupful finely chopped mint leaves and one-fourth teaspoonful of salt and a very little paprika. To this add one and one-fourth tablespoonfuls granulated gelatin which has been softened in a little cold water. Cool the mixture and stir until it begins to thicken and then pour it into small molds or glasses. The amount of mint may be increased if a stronger flavor is liked. This jelly can be kept only a short time.

Mint jelly is also made by flavoring apple jelly with green mint leaves. Two pounds of apples cut in quarters are cooked with water to cover until soft, as for ordinary jelly, and three cups of green mint leaves and tops are added about 10 minutes before the cooking is completed. To the juice drained from the apple and mint, three-fourths of a cupful of sugar and the juice of a large lemon are added, and the jelly is cooked until a little tested on a cold plate will harden. It is then strained into hot jelly glasses.

Housekeepers commonly tint jelly made by either method with a little vegetable green coloring matter.

Leg of Mutton Stuffed and Roasted.

For this purpose have the leg of mutton cut into two pieces and use the thicker end, which should be boned. Stuff the boned piece and tie into good shape. Roast in a hot oven, allowing about 10 minutes for each pound if the meat is desired rare, 15 if desired well cooked. In making the gravy, follow the directions on page 21.

Dressing for Roast Mutton.

1 pint stale bread crumbs.
½ cup cracker crumbs.
½ teaspoon sage.
2 tablespoons butter.
1 teaspoon sweet marjoram.
Salt and pepper.
Few drops onion juice.

Soak the bread in cold water. Press out nearly all the water, and add the other ingredients.

Roast Ribs of Mutton with Apples.

After wiping the meat, spread over the surface one finely chopped clove of garlic, one chopped onion, one-half teaspoon each of powdered thyme and marjoram, and one teaspoon of salt. Place on a rack and roast in a moderate oven from one and one-half to two hours, basting frequently. Place potatoes and sour apples around the roast, the former one hour before serving and the latter one-half hour. The apples will prove a palatable accompaniment to the roast and will impart their flavor to the gravy, which should be made according to directions on page 21.

Roast Mutton with Bananas.

Peel the bananas and bake them for 30 minutes under the mutton. Tart fruit relishes, such as spiced currants or those given below, may be served with the bananas.

FRUIT RELISHES WITH ROAST MUTTON.

1 cup prunes cut into small pieces.
1½ cups water.
3 tablespoons sugar.
½ teaspoon ground cinnamon.
2 tablespoons currant jelly.
Juice of ½ orange.

Boil together until the prunes are soft.

For the prunes in this recipe raisins or a mixture of equal parts of raisins and prunes may be substituted. One-fourth cup of butter is sometimes added.

These fruit relishes may be served also with sliced cold lamb or mutton and are very palatable.

Roast Mutton with Turnips.

Turnips are frequently cooked under roast mutton. They are sometimes stuffed. To prepare in this way, first parboil the turnips and then scoop out a portion of each by means of a spoon and fill the cavity with bread which has been soaked in cream or in milk to which a little melted butter has been added.

Baked Breast of Mutton.

Sew up a breast of mutton in a very thin cloth, put it into a stewpan, pour over it enough cold salted water to nearly cover it, and let it simmer, allowing 10 minutes to each pound. Then take it out of the saucepan and out of the cloth, put it in a baking dish, rub it over with mutton drippings. butter, or savory fat, sprinkle some flour over it, and bake for one-half hour in a hot oven, basting frequently with its own broth. Five minutes before taking it out of the oven strew fine dry bread crumbs thickly over it, put little bits of butter here and there, and let it brown. Serve with a brown sauce made from the broth in which the meat was cooked.

Mutton and Potato Pie.

1 pound mutton from the shoulder.
1 onion.
½ cup flour.
1 carrot.
6 medium-sized potatoes.
1 teaspoon baking powder.
1 tablespoon butter.
Salt.

Cook the onions, carrots, and meat together in water enough to cover. Boil the potatoes separately. Reserve enough of the potatoes to make a cup of mashed potatoes. Cut the remaining potatoes and the other vegetables and meat into small pieces, and place in a baking dish. Cover with some of the broth thickened with the flour. Mash the remaining potatoes. Add butter and salt. Mix this with the flour which has been thoroughly sifted with the baking powder. Spread this mixture over the ingredients in the baking dish, and bake in a hot oven until the crust is brown.

BROILING.

Broiling is a process closely akin to roasting, as the term was formerly used. It is performed over a clear fire, and relatively thin pieces of meat only are suitable for the purpose. The searing of the surface, which can be accomplished very quickly, is usually sufficient for the retention of the juices. In the case of meats having little fat, however, butter or other fat should be rubbed over the surface before the cooking is begun.

Chops from the loin or the rib, cutlets from the leg, or thick pieces cut from rare boiled or roasted mutton are suitable for broiling. When it is not convenient to broil, much the same results can be secured by pan broiling, i. e., cooking in a hot pan lightly greased.

Broiled Loin Chops.

Remove superfluous fat and roll the flank about the tenderloin, fastening it with skewers. Place on a broiler greased with some of the mutton fat. Cook from six to eight minutes, turning frequently during the first part of the time. A sauce of butter to which a little lemon juice and chopped parsley have been added is sometimes rubbed over the chops, or since the chops themselves contain much fat, lemon juice and parsley only may be used, or the chops may be served on thin slices of lemon. Onion sauce is by some people considered a great delicacy for serving with broiled chops.

Sauces for Broiled Loin Chops.

PARSLEY AND BUTTER SAUCE.

¼ cup butter.
½ teaspoon salt.
⅛ teaspoon pepper.
½ tablespoon finely chopped parsley.
¾ tablespoon lemon juice.

Cream the butter, add the salt, pepper, and parsley, and then the lemon juice very slowly.

ONION SAUCE.

6 large white onions.
¼ cup butter.
1 tablespoon flour.
1 teaspoon sugar.
½ cup cream.
Salt.

Cut the onions into two or three pieces each, and cook them for 10 minutes in boiling salt water. Strain them and cook in a covered saucepan with the butter for about three-fourths hour or until they are very tender. Press through a purée sieve and reheat. Sprinkle the flour over them, stirring it in thoroughly, and add the seasonings. Bring to the boiling point and heat long enough to cook the flour thoroughly.

Pan-Broiled Loin Chops.

Pan broiling is a method of cooking employed when there is no suitable fire for broiling. For best results it should be employed only in the case of meat from which most of the fat has been removed. Loin chops which are to be pan broiled should have the flank and most of the fat removed. After wiping they should be put into a hot frying pan and turned frequently. In order to avoid piercing the chops in turning them, they should be grasped between two forks or with a knife and fork. The time of cooking will depend, of course, upon the thickness of the chops and whether they are desired well done or not. From 6 to 10 minutes is the usual time. Pressing the chop against the side of the frying pan will help to complete the cooking. Pan-broiled chops may be served plain or with savory, tomato, or onion sauce. (See above.)

Sauces for Pan-Broiled Loin Chops.

SAVORY SAUCE.

To the fat in the pan in which the chops have been broiled add enough butter to make about two tablespoons. In this brown three tablespoons of flour and add one cup of water or stock. Season with salt and pepper and add one-half onion, finely chopped, and one tablespoon each of capers and finely chopped pickle.

TOMATO SAUCE.

2 tablespoons butter.
2 tablespoons flour.
Stewed or fresh tomato enough to make 1 cup when well boiled down.
1 stalk celery.
1 sliced onion.
Few cloves.
Salt and pepper.

Cook the tomatoes with the seasonings. Cook the flour thoroughly in the butter, strain the tomatoes, and add to them the butter and flour. Cook all together until smooth, stirring constantly.

Montana Steak.

1 pound lean mutton free from bone.
1 egg.
½ cup milk.
1 teaspoon salt.
⅛ teaspoon pepper.
Few drops onion juice.

Chop the meat finely, add the other ingredients, form into small cakes, and either broil or fry them. While this dish is more delicate if the egg and milk are used, it can be made without them. In this case it resembles very closely Hamburg steak as it is ordinarily prepared from beef. It may be made with or without onion.

FRYING.

Frying in deep fat is a method of cooking meat in which it is subjected to high temperature, and which imparts a distinctive flavor to the meat. It is a common custom to dip meat, fish, etc., cooked by this method, in egg and fine crumbs before immersing in the hot fat.

Fried Crumbed Mutton.

If thin pieces of mutton, either raw or cooked, are dipped in flour, then in egg, and then in crumbs and fried in deep fat, they lose less moisture than if broiled or panbroiled. This method is especially suitable for rib chops, thin loin chops, or small pieces cut from rare cooked meat. Thick chops would hardly be cooked through by this process.

Fried Rib Chops.

Wipe the chops and salt them on both sides, dip them in flour, and then in a mixture of egg and water in the proportion of one egg to two tablespoons of water and finally in fine cracker crumbs. Fry in deep fat at a temperature suitable for foods that have not been already cooked, which is about 350° F. In fat of this temperature a small piece of bread from the center of the loaf will become a delicate brown in one minute.

Chops prepared in this way are often served around a mound of mashed potatoes. This has the advantage of keeping the chops hot if the precaution has been taken to reheat the potatoes after they have been mashed. A depression may be made in the mound of potatoes for tomato sauce, which is a good accompaniment for this dish. Broiled or fried chops are sometimes served around mounds of peas, young carrots, turnips, fried green peppers, or a purée of beans.

To prepare the carrots for this purpose, boil them in water, pour off the water, and add a little butter, a very little sugar, and chopped parsley. Reheat.

To prepare green sweet peppers, which are an exceptionally good accompaniment for mutton, remove all the seeds, cut into thin slices, and cook in butter and a little water. Allow the water to evaporate after the peppers have become tender and cook them in the fat until they begin to brown, but not long enough to blacken them.

Another dish which is often served with mutton chops or roast mutton is a purée of navy beans.

Purée of Navy Beans to Accompany Mutton Chops and Roast.

1 pint beans.
1 onion.
1 carrot.
1 sprig parsley.
Pepper.
¼ pound salt pork or
2 tablespoons mutton drippings.
2 cloves.
½ teaspoon salt.
1 quart water.
1 tablespoon butter.

Soak the beans over night, drain, and add the other ingredients with the exception of the butter. Boil for 30 minutes and cook in a moderate oven for one hour. Remove the onions, carrot, and parsley and press through a sieve. Add butter and salt (if necessary) and reheat. Similar purées may be made from red kidney beans, split peas, and lentils.

WARMED-OVER MUTTON.

Since the successful recooking of mutton usually consists in utilizing well what happens to be on hand, both in the way of meat and also of vegetables or other accompaniments, it is difficult to give any definite recipes. In many cases the preparation of a dish involves simply the reheating of pieces of the cold meat in a gravy, and for this reason the principles of the making of gravies should be kept in mind in this connection. The proportions for a sauce of suitable thickness are two level tablespoons of fat and two of flour to each cup of liquid. The fat may be butter, drippings, or savory fat, and the liquid may be water, stock, milk, tomato juice, or a combination of two or more of these. Browning the flour in the fat is an easy way of securing variety. If this is done the thickening power of the flour is reduced and the amount used should be three instead of two tablespoons to one cup of liquid.

The following, which is capable of a large number of variations secured by using different fats, liquids, and seasonings, is a good sauce in which to reheat mutton. The possibilities in the way of flavoring by sweet herbs, peppers, pickles, capers, currant jelly, etc., have been suggested from time to time in this bulletin.

SAUCE FOR WARMED-OVER MUTTON.

1¼ cups white stock.
1 slice onion.
1 slice carrot.
1 sprig parsley.
2 peppercorns.
¼ cup butter.
¼ cup flour.
1 cup scalded milk.
½ teaspoon salt.
⅛ teaspoon pepper.

Cook the stock 20 minutes with onion, carrot, bay leaf, parsley, and peppercorn, and strain. There should be one cup. Melt the butter, add the flour, and gradually the hot stock and milk. Season with salt and pepper.

Mutton in Gravy.

Cold mutton reheated in gravy or sauce is served with rice, on toast, on baking-powder biscuits, with a pastry or biscuit crust, with a crust of mashed potatoes, or with a crust consisting of mashed potatoes and mashed turnips in proportion of 2 to 1.

Cutlets of Cold Mutton.

From a leg of mutton, which has been cooked rare, cut pieces about the size of an ordinary loin chop. These may be fried in a little fat, or egged, crumbed, and fried in deep fat, or they may be brushed over with fat and broiled. The result is like meat cooked for the first time rather than like the ordinary warmed-over meat. Cutlets thus prepared may be served with any of the sauces suggested for serving with chops.

Mutton and Tomato Pie.

An excellent way to use cold mutton is to bake it with tomatoes, using alternate layers of tomatoes and meat. A tomato sauce may be used or the following method may be employed: Place in a baking dish a layer of fresh tomatoes or of cooked tomatoes which have been either drained or reduced in volume by boiling. Add a layer of meat, dredge with flour, salt, and pepper, and add small bits of butter until the materials are used, arranging to have a layer of tomatoes on top. Cover this with a layer of buttered bread crumbs or cracker crumbs and bake until the crumbs are brown. In following this method use tomato, butter, and flour in the correct proportions for tomato sauce, i. e., two level tablespoons each of butter and flour for each cup of tomatoes.

Green Peppers Stuffed with Mutton.

Cut green peppers in two lengthwise and remove all the seeds. Fill with a mixture of equal parts of cold mutton and boiled rice well seasoned and moistened with a little stock or water. Bake until the peppers are tender.

Mutton Croquettes.

Like other meats, mutton may be used for croquettes. A general rule for making croquettes is to combine two cups of finely chopped cooked meat (or the same amount of a mixture of meat, rice, and potatoes, or other vegetables) with one cup of thick sauce. The sauce for this purpose is made by heating one-third cup of flour, or one-fourth cup of cornstarch, in three tablespoons of fat, and adding a cup of liquid which may be stock, water, milk, tomato juice, or a mixture. The amounts given above are those generally used, but the proportion of sauce to meat varies under different circumstances, as some substances absorb more of this sauce than others do. It is a common practice, though by no means necessary, to add the yolk of a raw egg. After the mixture of meat and sauce is cooled it is formed into rolls of uniform size which should be dipped first in flour, then in a mixture of two tablespoons of water and one egg, and finally in fine cracker crumbs. The temperature for frying croquettes is that for all foods which have already been cooked (about 400° F.). Fat (oil, lard, drippings, etc.) at that temperature will brown a piece of bread taken from the center of a loaf in 40 seconds.

Mutton and Caper Croquettes.

3 tablespoons savory fat.
⅓ cup flour.
1 cup mutton stock or milk.
2 cups finely chopped cold mutton.
1 tablespoon finely chopped capers.
Salt.

Make a sauce out of the fat, flour, and liquid, mix with the other ingredients, and follow the rules given above for making croquettes.

Mutton and Rice Croquettes.

In the above recipe, substitute one cup of cold boiled rice for one of the cups of mutton.

Mutton and Potato Croquettes.

In the recipe for mutton croquettes, substitute two-thirds of a cup of cold boiled potatoes cut into small pieces for one of the cups of mutton.

Steamed Mutton and Rice.

4 cups cooked or
1 cup raw rice.
2 cups cooked mutton cut into small pieces.
1 teaspoon salt.
¼ teaspoon pepper.
Few drops onion juice.
1 tablespoon chopped parsley.
¼ cup bread crumbs.
1 egg.
Stock or water.

Grease a mold or a bowl of about 1½ quarts capacity and line with cooked rice. Heat the meat with the other ingredients, using enough stock to make a mixture that is moist, but will hold its shape. Pack the meat in the center of the mold and cover with the remaining rice, grease the cover of the mold (if a bowl is used, a plate will serve for a cover), steam or cook in water enough to partly cover the mold until the contents are thoroughly heated through. Turn it on a hot platter and serve with tomato sauce.

The above recipe, it will be noted, suggests the use of bread crumbs instead of flour for thickening, which is often a way of saving bread which might otherwise be wasted, and which is also one way of securing variety, as a different texture results than when flour is used.

Mock Venison.

Cut cold mutton into thin slices and reheat in a sauce made in the following way:

2 tablespoons butter.
2 tablespoons flour.
1 cup water or stock.
¼ cup red currant jelly.
1 tablespoon catsup or other meat sauce.
Salt.

Make a brown sauce out of the butter, flour, and water or stock. Add the jelly and other flavorings.

Turkish Stuffed Tomatoes.

In Turkey a number of dishes are prepared from mutton which are interesting from the point of view of the food customs of another country, and also palatable. The recipes here given have been modified somewhat to accord with our usual habits of cookery. One of them involves the use of broken rice, which can easily be prepared by the use of an ordinary meat grinder. The following recipe for stuffed tomatoes is little different from many used in this country:

Two tablespoons cooked rice, one-half pound raw mutton, two onions. Pass the materials through a meat grinder; season with salt, pepper, and chopped parsley; fry in a pan for 10 minutes, stirring constantly. Wash one dozen smooth round tomatoes, cut a thin slice from the stem end, leaving a little of the skin for a hinge, remove the seeds and pulp, and fill with the meat mixture. Bake in a pan for 20 minutes, lift out with a broad knife and serve hot.

Mutton and Eggplant Pie.

Eggplant pie is a simple and well-seasoned dish made from a vegetable which has no marked flavor. It is made by cooking together in a baking pan alternate layers of eggplant and of chopped mutton fried in its own fat. Sometimes a little tomato juice is added or a few sliced tomatoes. It should be baked until well browned.

Mutton and Rice Rolls.

A characteristic Turkish dish is "sarma" or rolls made of meat and broken rice wrapped in grape leaves and then boiled. An acceptable substitute for this dish and one more in accord with common methods may be made by cooking chopped mutton and rice in a baking dish lined with slices of tart apple, which gives an even more pronounced tart flavor than the grape leaves, or the following recipe may be used:

Mutton and Cabbage-Leaf Rolls.

1 cup raw chopped mutton.
2 tablespoons fat.
⅛ cup raw rice.
2 teaspoons salt.
¼ teaspoon pepper
1 head cabbage.
1 lemon

Throw cabbage leaves of suitable size into boiling water and let them stand until they are wilted. Mix the remaining ingredients (with the exception of the lemon) and form into rolls, each containing about 1 tablespoon. Wrap each roll in a cabbage leaf, removing the thicker part of the stem of the leaf if necessary in order to roll it well. Pack these rolls closely into the baking dish and cover with water or stock. Bake one-half hour. Just before serving squeeze the juice of a lemon over them.

Or serve with the following:

SOUR BUTTER SAUCE FOR MUTTON AND CABBAGE-LEAF ROLLS.

1 tablespoon chopped pickle.
1 tablespoon chopped parsley.
2 tablespoons butter.
2 tablespoons mutton fat (savory or plain rendered).
3 tablespoons vinegar (spiced vinegar from pickles preferable).
Salt and red pepper to taste.

Beat the butter and mutton fat with a spoon until smooth, then beat in the vinegar until the sauce looks light colored and the vinegar has all been taken up. Add 1 tablespoon of finely chopped pickles and 1 tablespoon of finely chopped parsley.

MUTTON WITH FRUITS.

In the Orient it is a common custom to cook mutton with various fruits. Quinces, pears, apricots, and prunes, either fresh or dried, are used for this purpose. The fruit and meat should be cooked separately and reheated in combination. Some recipes direct that the meat be browned before cooking in water, others that it simply be stewed in water. Of the many recipes that might be given the following, based on oriental recipes, are selected:

Mutton with Quinces.

For this recipe use any cut of mutton suitable for stewing and twice its weight of raw quinces. Cut the meat into small pieces and brown them either in mutton fat or butter. Cover with boiling water, add salt, and cook slowly until tender. Pare and quarter the quinces and cook them in a small amount of water until tender. Combine the meat with the fruit and cook slowly for 10 or 15 minutes. Serve with rice. Variety may be obtained by making a brown gravy with the fat in which the meat is fried (see recipe, p. 21) and cooking the meat in that.

Mutton with Sour Apples.

In the above recipe sour apples may be substituted for quinces.

Mutton Baked with Apples and Onions.

2 pounds mutton cutlets from neck.
Salt.
1 onion.
4 medium-sized apples.

Prepare the meat by removing the bone and superfluous fat. Season with salt and lay in a baking dish. Cover the meat with finely sliced sour apples and finely chopped onions. Bake in a moderate oven until the meat is tender, which will be about one hour.

CORNED MUTTON AND ITS USES.

The following directions for corning mutton are a modification of those given in an earlier bulletin of this series.[1] For convenience, the amounts are changed so as to be suitable for the quantity of meat which would usually be used in the home. If larger quantities are corned, the quantities should be increased proportionately. The shoulder is the cut most frequently corned. The leg is delicious corned, but it is too expensive to be used in this way except for the purpose of preserving it.

10 pounds mutton.
1½ cups salt.
½ tablespoon baking soda.
1 tablespoon saltpeter.
¾ cup brown sugar.

Rub the salt thoroughly into the meat, covering every portion, and allow the meat to stand with the salt on it for 24 hours; then pour over it the other ingredients dissolved in a small amount of lukewarm water. Add water enough to cover the meat, and allow the meat to stand in the brine for at least three or four days. Meat thus corned will keep in good condition for a long time. Since mutton absorbs salt more readily than beef, special care should be taken to avoid using too much of it.

Corned mutton may be used in all the ways in which corned beef is used. The broth in which it is boiled makes good soup when seasoned with onion and turnip or other vegetables.

MUTTON SAUSAGES.

Sausage can be made from mutton mixed with pork in much the same way as beef is used for similar purposes. A general formula would be: Mutton, 2 parts; lean fresh pork, 1 part; and fat pork, 1 part; with salt and seasoning to suit the taste. Such sausage can be made into cakes and cooked at once or may be packed in skins or bags in the usual way. Homemade sausage is very commonly kept frozen. When this is not possible, it is often convenient to make small quantities for immediate use.

Mutton Sausage No. 1.

1 pound mutton free from bone.
½ pound fat fresh pork.
¼ teaspoon black pepper.
½ teaspoon salt.
¼ teaspoon each, marjoram, thyme, and sage.

Put the meat through a sausage or meat grinder, and mix thoroughly with the other ingredients. Pack in a bag about 2½ inches in diameter and keep in a very cool place. Cut into slices and fry. If it is to be used at once packing in a bag is not necessary; instead the chopped and seasoned meat may be made into cakes.

---

[1] U. S. Dept. Agr., Farmers' Bul. 186.

Mutton Sausage No. 2.

½ pound mutton free from bone.
½ pound veal.
½ pound salt pork.
¼ teaspoon salt.
¼ teaspoon each, marjoram, thyme, and sage.
⅛ teaspoon black pepper.

In preparing the sausage, follow the directions for Mutton Sausage No. 1.

SUMMARY.

Many experimental studies of the relative nutritive value of different kinds and cuts of meat, the losses sustained in cooking meat in different ways, the thoroughness of digestion of meat and the effect on palatability and economy of different methods of preparing it for the table, and similar questions have been studied in connection with the nutrition investigations of this office.

Mutton and lamb have been widely used in many countries since early times as staple foods. In later years lamb has been the more popular of the two in the United States, perhaps because special attention has been given to raising lamb for the market and to extending its season. The whole question is simply one of taste, and mutton in some form or other has always been a staple and a favorite food. That it is wholesome as well is generally believed, and this is borne out by inspection work of the Department of Agriculture, which shows that it is relatively seldom that mutton has to be rejected as unfit for food.

In composition and nutritive value mutton is practically the same as beef, and the average loss of weight in preparing the two kinds of meat for the table is also practically the same.

Buying in quantity is recognized as an economic procedure where the housewife has facilities for storage. There are many cases in which a side of mutton can be economically purchased for home use where a side of beef is too large for such a purpose, which implies an economy in the selection of mutton.

As regards digestibility, there is no practical difference in beef and mutton, both being very thoroughly assimilated. The characteristic flavor of mutton is commonly said to have its origin in the fat. It is generally relished, and may be developed or modified by various methods of cookery to meet the tastes of the family. That mutton fat can be used in the household in many ways has been demonstrated by experiments which have been made with it.

The ways in which mutton can be prepared for the table are very numerous. Some of these are well known to the housewife, and others are less familiar. All are worthy of a trial, since the ability to make many dishes with any given foodstuff is an easy way of securing variety in the diet, which is so desirable. The housewife who wishes to economize can make many savory dishes from the inexpensive cuts of mutton, which are palatable as well as wholesome.

Judged by its composition, palatability, wholesomeness, digestibility, relative cost, and the number of ways in which it can be prepared for the home table, mutton is an important foodstuff, which is well worth the attention of the housekeeper who wishes to provide her family with an attractive and palatable diet at a reasonable cost.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 527.

Experiment Station Work,

LXXIV.

Compiled from the Publications of the Agricultural Experiment Stations.

UNIVERSITY OF VIRGINIA
GENERAL
1879

PEONIES.	RETAIL BUYING OF BEEF.
SPRAYING POTATOES.	TOBACCO DIPS FOR SHEEP SCAB.
MARKETING WOOL.	SEWAGE DISPOSAL FOR RURAL HOMES.

JANUARY, 1913.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

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1913.

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[1] Director. [2] Special agent in charge. [3] Acting director.

EXPERIMENT STATION WORK.

Edited by W. H. BEAL and the Staff of Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

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EXPERIMENT STATION WORK.[1]

PEONIES.[2]

The peony is one of many old-time flowers which have experienced a decided modern improvement and revival of popularity. This is shown by the recent rapid growth of its culture and by the larger number of varieties that are being originated and propagated by the trade. The American Peony Society has for several years been co-operating with the Cornell Experiment Station in the study of the nomenclature and classification of the peony (fig. 1), and the station has recently issued its fourth report on this work. This and previous reports give descriptions of 626 varieties, including probably 95 per cent of the important commercial varieties. Those in charge of this

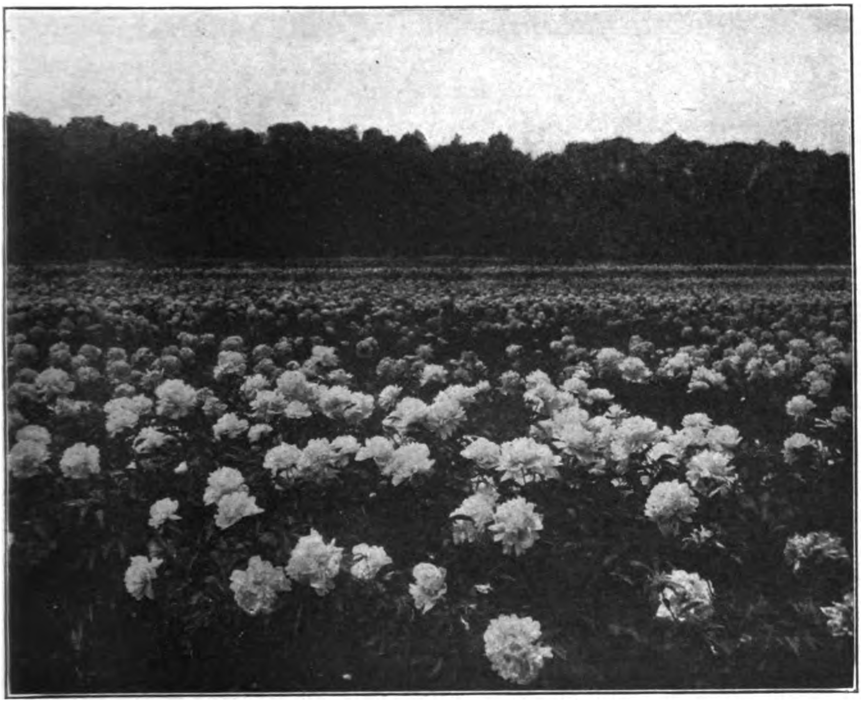

FIG. 1.—Field of peonies in which studies of synonymy were made.

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[1] A progress record of experimental inquiries published without assumption of responsibility by the department for the correctness of the facts and conclusions reported by the stations.

[2] Compiled from New York Cornell Sta. Buls. 259, 278, 306.

work have, however, been strongly "impressed with the large number of only medium varieties which are being continually originated and propagated by the trade."

It is probably a conservative statement to say that the peony interests of the country would be better off if about 75 per cent of the varieties were destroyed and future propagation made from the remaining 25 per cent of superior varieties. It is not that these 75 per cent of the varieties are positively unattractive; far from it. But the remaining 25 per cent fill every purpose and have many more virtues than the only medium to inferior sorts. By discarding the mediocre or poor sorts and selling only the more desirable varieties the customers would be even more infatuated with this beautiful flower, and a more extensive and higher-class trade would be built up, to the benefit of all concerned.

Varieties recommended for cut flowers and landscape or border planting are as follows:

LIST OF VARIETIES RECOMMENDED BY THE AMERICAN PEONY SOCIETY.

For Cut Flowers.

White.—Festiva Maxima, Couronne d'Or, Duchesse de Nemours, Baroness Schroeder, Albatre, Alba Sulfurea, Madame Crousse, Madame Calot, Madame de Vernéville, Boule de Neige, Avalanche, and Duc de Wellington.

Pale pink.—Achille, Albert Crousse, Dorchester, Floral Treasure, La Perle, Madame Lemoine, Marguerite Gérard, Marie d'Hour, Miss Salway, Mademoiselle Léonie Calot, Madame Émile Gallé, and Venus.

Pink and white.—Gloire de Charles Gombault, La Tulipe, and Jeanne d'Arc.

Deep pink.—Madame Ducel, Lamartine, Monsieur Jules Elie, Livingstone, Monsieur Boucharlat aîné, Souvenir de l'Exposition Universelle, Madame Lebon, Général Bertrand, Modeste Guérin, Edulis Superba, Alexandre Dumas, Madame Muyssart, and Kelway's Queen.

Red.—Félix Crousse, Louis Van Houtte, and Henry Demay.

Deep red.—Delachei, Prince de Talindyke (?), Constant Devred, Nigricans, Madame Becquet, Pierre Dessert, and Rubra Superba.

For Landscape.

White.—Octavie Demay, Marie Jacquin, Baroness Schroeder, Albâtre, Duchesse de Nemours, Alice de Julvécourt, Madame de Vernéville, Festiva, Marie Lemoine, Couronne d'Or, Madame Bréon, La Rosière, Albiflora the Bride, Avalanche, and Festiva Maxima.

Pale pink.—Achille, Eugène Verdier, Eugénie Verdier, Dorchester, Floral Treasure, Marie d'Hour, Triomphe de l'Exposition de Lille, Venus, La Perle, Marie Crousse, and James Kelway.

Pink and white.—Embellata Rosea, Golden Harvest, Madame Costé, Madame de Vatry, Thérèse, Princess Beatrice, Beauté Française, and Philoméle.

Deep pink.—Madame Ducel, Livingstone, Monsieur Boucharlat aîné, Souvenir de l'Exposition Universelle, Madame Lebon, Général Bertrand, Modeste Guérin, Edulis Superba, Madame Muyssart, Alexandre Dumas, and Modèle de Perfection.

Red.—Fulgida, Félix Crousse, Augustin d'Hour, Louis Van Houtte, De Candolle, Henry Demay, and Dr. Caillot.

Deep red.—Delachei, Monsieur Martin Cahuzac, Stanley (Kelway). Raphael, Madame Becquet, and Adolphe Rousseau.

ADVANTAGES OF SPRAYING POTATOES.[1]

Potato growers have long realized that in seasons when blight is present spraying will check the blight and considerably increase the yield, but some growers have doubted that spraying is profitable on the average. It is impossible to foretell the appearance of blight, but since the disease generally does not appear every year, the tendency has been not to spray regularly in the belief that the aggregate gains will not repay the expense of spraying for a series of years. The 20 years' potato-spraying experiments at the Vermont station and 10 years of similar work at the New York State station recently completed answer the question as to the profitableness of spraying potatoes regularly in the affirmative and show such a margin of profit therefrom that the subject should command the earnest consideration of all potato growers.

In a previous bulletin of this series[2] attention was called to the work at the New York State station. The work at the Vermont station was begun in 1891. In the early experiments comparative tests of different fungicides were made, but the superiority of Bordeaux mixture soon became apparent, and in the subsequent years Bordeaux alone was used. The results showed conclusively that Bordeaux mixture very efficiently protected plants from the attacks of the early and of the late blight and seemed to serve in some way as a stimulus to the plant, so that it remained green from one to two weeks longer than the unsprayed plants and also yielded more and larger tubers.

The physiological effect on the plant is shown by the fact that even early in the season the sprayed plants stored more starch in their tubers than those not so treated. While the plants themselves from the sprayed and the control plats were of approximately the same size, "the weight of the tubers at this time was 24.8 bushels per acre in favor of the potatoes to which the Bordeaux had been applied. This would seem to indicate that during the months of July and August. while the tubers were growing, the unsprayed plants were not able to fix as much carbon dioxid and transform it into starch as were those that had not been so treated."

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[1] Compiled from New York State Sta. Bul. 349 (and 349, popular edition); Vermont Sta. Bul. 159.

[2] U. S. Dept. Agr., Farmers' Bul. 251, p. 9.

The results of the entire 20 years' work at the Vermont station show that—

> Bordeaux mixture, even in years like 1910 when no blight occurs, increases the yield of the plants to which it is applied. This increased yield is always sufficient to pay for the cost of spraying operations. Spraying is to be regarded as an insurance that pays for itself. If the blights are prevalent, the potatoes, if thoroughly sprayed, are insured against loss therefrom; if the season is a dry one and no disease occurs, still the crop will be enough larger to pay for all the cost of spraying. The careful potato sprayer wins either way, no matter what the weather or disease conditions.

The results with iron sulphate-copper sulphate mixture indicate that Bordeaux mixture "in which part of the copper is replaced by iron has as great a stimulating effect as does the ordinary Bordeaux. Whether it is as good a fungicide has not yet been proved."

> The increased yields from plats where the Bordeaux mixture was applied only to part of each plant indicates that even here there was a sufficient effect produced to manifest itself in a yield of 28 bushels per acre more than that obtained on the plats left entirely untreated. This is about what would be expected if half the leaves were touched by the Bordeaux.

The following table gives the results of the 20 years' spraying experiments, showing yields from the plats sprayed with Bordeaux mixture as compared with the control plats:

Gains from the use of Bordeaux mixture on late potatoes.

Planted.	Sprayed.	Yield per acre.		Gain per acre.		Prevalence of late blight.
		Sprayed.	Not sprayed.			
White Star:		*Bushels.*	*Bushels.*	*Bushels.*	*Per cent.*	
May —, 1891	Aug. 26, Sept. 8	313	248	65	26	Some.
May 20, 1893	Aug. 1, 16, 29	291	99	192	194	Much.
Do	do	338	114	224	196	Do.
Apr. 26, 1894	June 16, July 17, Aug. 30	323	251	72	29	None.
May 20, 1895	July 25, Aug. 13, 31	389	219	170	78	Rot.
Polaris:						
May 15, 1896	Aug. 7, 21	325	267	68	26	None.
June 1, 1897	July 27, Aug. 17, 28	151	80	71	89	Some.
White Star: May 10, 1898	July 21, Aug. 10	238	112	126	112	Little.
Average: 3 varieties, May 18, 1899	July 26, Aug. 17, Sept. 8	229	161	68	42	Do.
Delaware:						
May 23, 1900	Aug. 4, 23	285	225	60	27	Rot.
May 25, 1901	July 20, Aug. 21	170	54	116	215	Much.
May 15, 1902	Aug. 1, 20	298	164	134	82	Severe.
Green Mountain: May 1, 1903	Aug. 10	361	237	124	52	Do.
Delaware:						
May 25, 1904	Aug. 1, Sept. 1	327	193	134	69	Some.
May 15, 1905	Aug. 2, 21	382	221	161	73	Severe.
Green Mountain:						
May 27, 1906	Aug. 13, 22	133	101	32	32	Some.
May 1, 1907	July 16, 25, Aug. 8, 22	171	63	108	175	Little.
May 15, 1908	June 26, July 9, Aug. 6, 26	156	65	91	140	None.
May 28, 1909	July 12, 23, Aug. 6, 27	243	188	55	29	Do.
May 9, 1910	July 11, 27, Aug. 15, 23, 30	240	202	38	18	Do.
	Average for 20 years	268	163	105	64	

In applying the mixture it is important to cover the plants uniformly and very thoroughly. The following directions for spraying are given by the New York State station:

> In general commence spraying when the plants are 6 to 8 inches high and repeat the treatment at intervals of 10 to 14 days, in order to keep the plants well covered with Bordeaux throughout the season. During epidemics of blight it may be advisable to spray as often as once a week. Usually six applications will be required. The Bordeaux should contain 4 pounds of copper sulphate to each 50 gallons in the first two sprayings and 6 pounds to 50 gallons in subsequent sprayings. Whenever [potato] bugs or flea-beetles are plentiful add 1 or 2 pounds of Paris green, 2 quarts of arsenite of soda stock solution or 3 to 5 pounds of arsenate of lead to the quantity of Bordeaux required to spray an acre.
>
> Thoroughness of application is to be desired at all times, but is especially important when flea-beetles are numerous or the weather favorable to blight. The more frequently and thoroughly the plants are sprayed the better. There is no danger of injuring the foliage by too much spraying. Using the same quantity of Bordeaux, frequent light applications are likely to be more effective than heavier applications at long intervals; that is, when a horsepower sprayer carrying but one nozzle per row is used, it is better to go over the plants once a week than to make a double spraying once in two weeks. In the first two sprayings, while the plants are small, one nozzle per row may be sufficient, but when the plants become large at least two nozzles per row should be used. Large vines are especially liable to blight and should be sprayed very thoroughly. Such vines will be somewhat injured by the wheels of the sprayer, but the benefit from spraying will far outweigh the damage done.
>
> A single spraying is better than none and will usually be profitable, but more are better. Spraying may prove highly profitable, even though the blight is only partially prevented. It is unsafe to postpone spraying until blight appears. Except, perhaps, on small areas, it does not pay to apply poison alone for bugs. When it is necessary to fight insects Bordeaux mixture and poison should be used together. For the best results spraying should be continued as long as the plants live. It is a mistake to discontinue spraying because the weather is dry and no blight present. A late attack of blight may result in heavy loss from rot. As a rule those who spray most obtain the largest net profit.

The foregoing statements show that thorough spraying of potatoes every year has three distinct advantages which make it profitable: (1) It insures against loss from blight; (2) it protects against insect damage; and (3) it stimulates the growth and thus increases the yield.

MARKETING WOOL.[1]

An adequate knowledge of the requirements of the market and attention to those requirements are necessary in order to obtain the best prices for any commodity, and this applies just as much to the sale of wool as to any other branch of trade. The common practice of selling wool to local storekeepers, who are compelled to pay as much to one man as to his neighbor, irrespective of the value of the wool, and the consequent lack of knowledge on the part of the wool producer of the requirements of the market, have been great drawbacks to the proper development of the wool industry in this country. All kinds and grades of fleeces are sold in the same bag, resulting in a mixed and undesirable lot of wool. The commission merchant samples and buys the whole consignment on the basis of the cheapest and most inferior wool, and besides often discounts the seller for mixed packing. The producer suffers the loss.

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[1] Compiled from Illinois Sta. Circ. 161; Mo. Cons. and Trade Rpts. [U. S.], 1910, No. 357, pt. 2, p. 207.

In would seem, therefore, that any suggestions as to the proper preparation of the wool product for the market would be of particular value. As W. C. Coffey, of the Illinois station, points out—

> In these days we, as producers of wool, are absolutely dependent on the market for the disposal of our product. The day of homespun is gone. The world supply of wool is limited to such an extent that we may be confident of receiving a profitable return on our wool crop if we only do our share in meeting market requirements. * * *
>
> Those familiar with the ways of growing and preparing wool for market in the countries of greatest production admit that the United States is behind in her methods. Since the wools produced in the farm flocks of the central and eastern parts of our country come in direct competition with foreign wools, carefully grown and prepared for market, better methods are imperative if satisfactory profits are to be made on the wool crop.

The breeding, feeding, and general health of the flock are, of course, very important factors in determining the quality of the wool. In general it may be said that the English Down mutton breeds, such as the Shropshire, Oxford, and Hampshire, produce wool which will meet with ready demand, so that the specialized wool-producing breeds need not necessarily be chosen. By using pure-bred rams of the same breed for a series of years a flock can be graded up so that the type of wool will be sufficiently uniform to satisfy the demands of the market, provided proper attention is paid to the fleeces of the rams purchased and of the ewes reserved for breeding.

One of the most general criticisms made against the wools produced in farm flocks is in regard to the foreign substances the fleeces contain.

> Some of these substances get into the wool while it is on the sheep, while others gain entrance through faulty methods of shearing and packing. If there is a great deal of foreign material in wool, it is impossible to remove all of it through the process of scouring. If it is left in, the result is a fabric with noticeable defects; if it is removed, it is by treating with a weak solution of sulphuric acid and heating (a process known as carbonizing), which may weaken the wool fibers. This not only lowers the value of the wool for manufacturing purposes, but also adds to its cost to the manufacturer, because he has to spend upon it the extra labor of carbonizing. * * *
>
> Carelessness in feeding causes a great deal of foreign material to be deposited in wool. Racks for roughages such as hay, fodder, and straw, should

be constructed so that chaff can not fall out and lodge on the shoulders and necks of the sheep. Barns and lots should be arranged so that it is unnecessary to pass amongst the sheep in carrying loose straw to the racks. It is well to remember that the equipment necessary to keep chaff and litter out of the wool, as suggested above, also results in a saving of feed. Usually that which sifts out and is lost is the most palatable and nutritious part of the feed; hence there is good reason for keeping it out of the fleece aside from he damage it does to the wool.

Care should be taken to keep dirt and dung out of the wool; neither of these damages wool as much as burrs, chaff, and litter, but they do some damage, and they most certainly make it less attractive to the buyer and add to the shrinkage in the process of scouring. Sheep should not be forced to lie in mud, nor should they be allowed to lie in dusty places. Those who run their sheep on plowed lands have difficulty in providing clean resting places for them, and we can not expect the wool to be as clean as it would be were their sheep kept on pastures. Tags of dung in wool are very objectionable to buyers. They are very heavy, and since they usually contain much moisture they often cause the wool to mold. There is no excuse for wrapping dung tags in wool if proper care is taken at shearing time, but it is better to handle sheep so that comparatively little dung will cling to the wool. All the sheep in the flock should be docked, and, late in the autumn, the wool should be sheared off around the dock. Dung clings to the wool only when the feces are soft or when the animal is scouring. When the animal scours it should have a change of feed and possibly medical attention, so that a case of chronic scours will not develop. If these suggestions are put into practice, there are not likely to be many dung tags at shearing time.

PAINT AND TAR MARKS.

Oil paint and tar marks are very objectionable in wool, but their use is not common in farm flocks. They are objectionable because they can not be removed in scouring. The manufacturer is obliged to employ labor to cut them out before the wool is scoured. This reduces the length of the wool to such extent that its value is impaired. The paint and tar clippings are of very low value, and hence the objection to them is thrice emphasized. In case it is desirable to wool brand, there are marking inks or fluids on the market which do no damage to the wool, because they come out in the process of scouring.

This subject is more fully discussed in a previous bulletin of this series.[1]

SHEARING.

The quality of the fleece depends to some extent upon the time of shearing, early shearing (in March) being preferable if practicable. Careful shearing in a clean place to secure clean, uniformly cut, untorn fleeces is another requisite of quality.

TYING THE FLEECE.

After shearing, the next important step is tying the fleece. Several things must be done to make this job a good one. First, all tag locks must be removed whether they be of dung or grease and dirt. Second, the fleece should be carefully rolled up by hand (not in a wool box), with no ends and stray locks protruding, and with the flesh side out. Third, the fleece should be tied with a hard, glazed twine, not larger than one-eighth inch in diameter. In tying the ends of the twine especial care should be taken to make a firm, hard knot that will not slip.

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[1] U. S. Dept. Agr., Farmers' Bul. 522, p. 20.

The tied-up fleeces should contain nothing but merchantable wool. Weighty materials, such as bricks, stones, and sheep heads, should not be rolled up in fleeces, and fortunately such instances are relatively few. But tag locks are so common that their presence in fleeces from farm flocks is the rule rather than the exception. The total effect of such a practice is bad. It puts our wools in bad standing with wool houses and manufacturers. Long continued, it has led to the only logical result, namely, discrimination in price against our wools.

Careful rolling, with the flesh side of the fleece out, and no ends or stray locks showing, adds greatly to the appearance of the fleece. It also prevents mixing the wool in different fleeces; and, by the way, each fleece should be tied to itself. In wool warehouses it is a pretty sight to see the heaps of graded wool faced with a tier of carefully rolled and tied fleeces.

TYING TWINE.

The use of wrong kinds of tying twine has caused the manufacturer more trouble than any other one thing, with the wools marketed from the farms of the central and eastern United States. A hard, glazed twine should be used in order to avoid getting any of its fiber mixed with the wool. During the last three or four years paper wool twine has been introduced which is entirely satisfactory to the manufacturer. Rough, loosely woven twine made of vegetable fiber is not desirable, because some of the fiber gets into the wool. It is impossible to remove it. It will not take the dyes used in coloring wool, and it is detrimental to the strength and finish of the cloth. The only way to get rid of it is to pick it out of the finished cloth, which is an expensive process. Sisal twine is the most objectionable of all employed for tying wool. The mills have objected to it so strenuously that its use is being largely discontinued. In no event should it be used; better not tie at all than use it. There have been placed on the market jute products, called wool twine, which are not at all satisfactory. They are so loose and rough that many of the fibers cling to the wool and cause defects in the goods. Undoubtedly the wool trade the world over will institute a war against this type of twine. These so-called wool twines are also unnecessarily heavy. The best wool buyers object to excessive size and length of string. A well-known wool house in the Middle West informed the writer that they had removed more than one pound of twine from a single fleece. The use of so much cheap stuff amounts to unfair packing. It is not necessary to wrap the string more than three times around the fleece—twice is usually sufficient—and the size of the string should be no greater than needed to give it the strength to stand the strain of drawing it in tightly on the wool for the purpose of tying. As stated above, it should not be more than one-eighth inch in diameter. "India" three-ply size No. 4½ is a type suitable for tying wool; so are the paper wool twines. Some of the latter, however, are stiff, and therefore difficult to tie in a firm, hard knot that will not slip and release the wool. In selecting from them care should be taken to secure a kind that is soft and pliable.

PACKING AND STORING.

When packing, the fleeces of ewes, lambs, rams, and wethers should be packed separately. In small flocks it is hardly advisable to pack them in separate bags, but they can be separated in the bag by sheets of stiff, strong paper, so that they can be easily sorted at the market. A bag containing a certain kind or kinds of wool should be marked so that its contents are known. Tags and wool from dead sheep should be packed separately. If there are black or gray fleeces, either they should be packed separately or their location should be designated. For example, a bag containing 40 ewe fleeces, 2 of which are black, could be marked as follows: 38 white—2 black.

If the wool is not sold immediately after shearing, it should be stored in a clean, dry place. It should not be left on the bare ground, even though it is placed in bags. It is the better method to store and market wool in bags, as it is the more likely to be kept clean. The bags should be closely woven, so that they will effectively keep out dust and dirt. They should also be of a type that will not shed particles of fiber into the wool. The loosely woven jute bags commonly used are satisfactory in neither particular. In Australia the bags or sheets are lined with paper to insure keeping the wool clean.

A recent number of the Monthly Consular and Trade Reports describes a new method of packing and heading the bales in use in Australia by which the twine is prevented from entering the wool.

The demonstrations of the new process seem to have won the approval of the trade, both in Australia and at Bradford. The equipment necessary for the new process is now obtainable by all pastoralists and exporters desirous of using it, and its popularity seems to be gaining steadily. The demonstration of this new process has been one of the most interesting and closely noticed features of recent agricultural shows in Australia.

In packing wool by this new process, packs with prepared heads and loose tops must be used for the purpose. The pack and the loose head are placed in the wool press in the usual way, the packs being cut down 15 inches from the top. No further cutting is required. After the bale is pressed the front and back flaps are thrown temporarily over the bale, and the head is then firmly secured to the bale by two steel skewers, both front and back, at the same position as the stitching is done under the old system. While the bale is in this position it is not necessary to cut down the four corners, even when they project considerably, as when the skewers are released the corners fill up and form a stiff, even surface, making a package much superior to the old bale. The front and back flaps are tacked together in two places across the top of the bale about 8 inches from each side. The side flaps are then brought the usual way, tacked, and lock-stitched, and the skewers may then be released from the bale.

The chief feature of this process is that no twine or string can possibly enter the bale, the only stitching necessary being on the two outside flaps. There is also a great saving of twine, as nine bales can be treated with the same quantity of twine which, under the old system, was used on one bale. Another important feature is that by simply cutting the stitching on two outside flaps the bale is ready for inspection by the wool valuers and buyers.

In England and Scotland the bagging or sheeting is made from selected fiber of the best long hemp, thoroughly scoured after weaving and carefully examined before it is cut up into sheets. We must exhibit the same sort of care if we are to keep pace with these countries in the quality of the product we offer for sale. If the clip is contracted for before it is shorn and immediate delivery is planned, it is not necessary to bag the wool unless at the request of the purchaser. If it is packed in a clean wagon box and a canvas is thrown over the top, it can be delivered in desirable condition.

RETAIL BUYING OF BEEF.[1]

In a previous bulletin of this series[2] market classes and grades of meat were described. An understanding of the meat-trade requirements enables the stockman to judge the carcass yield and the quality of his animals. The breeder, by processes of selection, endeavors to produce a product which shall approach as near as possible an ideal type, and he recognizes the utility of the finished beef product as an important factor in his breeding operations. The practical feeder likewise requires an intimate knowledge of the market requirements of meat, and no doubt serious financial losses have often been experienced through a lack of knowledge of the proper degree of fatness and hence the amount of food required for each class to enable it to be sold to the best advantage. Thus the study of market requirements as to different wholesale cuts of meat has been given prominent yet by no means undue consideration.

As a contrast to this, the study of the relative proportion of the different kinds of meat in the retail cuts and the cost thereof on the basis of actual food value has been given very little attention in spite of its importance, to which the current high prices of beef have added a special significance. As L. D. Hall and A. D. Emmett, of the Illinois station point out, precise knowledge of the final market product into which beef cattle are converted is essential to both the producer and the consumer of beef. The consumers have to deal directly with the market and have occasion almost daily to make use of information concerning the relative values of different retail cuts. To buy meat intelligently it is necessary to know the nature of the cuts, especially with reference to the proportions of lean meat, fat, and bone they contain, and the food value of meat from different parts of the carcass.

A large majority of meat consumers have no knowledge whatever of these matters, but make their selections of meat solely according to habit or fancy. In fact, but little accurate data along this line have hitherto been available to those who wished to buy meats on a rational basis. As a result, a few well-known cuts are greatly in demand, and the remainder of the carcass is a "drug on the market." To such an extreme has this condition developed that a portion of the carcass (loins and ribs), forming only about one-fourth of its weight, represents nearly one-half of its retail cost. In view of the large place which meat occupies in the American diet, amounting to nearly one-third of the average expenditure for all food, the importance of an intelligent understanding of the subject on the part of the consumer is readily apparent.

Not only are the foregoing statements true of meat producers and consumers as individuals, but it is highly essential to the entire beef-cattle industry, on the one hand, and the economic welfare of the beef-eating public, on the other, that a more intelligent understanding of the different cuts of meat be acquired by consumers generally. An increased demand for those portions of the carcass which are now difficult for the butcher to dispose of would contribute largely toward a more stable condition of the trade and thus enable the producer to operate with greater confidence and economy. At the same time it would effect a tremendous saving to the consumer himself by more nearly equalizing the market values of the various cuts and by enabling the retailer to operate with a smaller margin of profit.

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[1] Compiled from Illinois Sta. Bul. 158.
[2] U. S. Dept. Agr., Farmers' Bul. 435, p. 16.

In the experiments at the Illinois station, three each of choice and prime steers from the university herd where slaughtered and determinations made of (1) the relative proportions of lean, visible fat, and bone in each of the retail and wholesale cuts of beef; (2) the chemical composition and nutritive value of the boneless meat of the various wholesale cuts; and (3) the net cost to the consumer of the lean, the gross meat, and the food nutrients in each cut at current market prices.

The relative cost of the lean and of the total meat in the straight wholesale cuts at market prices is shown in the following table:

Cost of lean and of total meat in the straight wholesale cuts at market prices.

Straight wholesale cuts.	Wholesale price per pound of cut.	Cost per pound of lean in cut.	Cost per pound of total meat in cut.
	Cents.	*Cents.*	*Cents.*
Loin	18.5	31.6	20.5
Rib	15.0	27.1	17.5
Round	11.5	17.8	13.9
Chuck	9.5	13.7	10.8
Plate	8.0	15.8	8.7
Flank	8.0	22.0	8.0
Fore shank	5.0	10.5	8.4

The net cost per pound of lean is, in general, greatest in the cuts which command the highest prices, and vice versa. The flank is an exception to this rule, and the chuck is more economical in this respect than the plate. Referring to the last column, it is also observed that the more expensive the cut the greater the cost per pound of visible fat and lean combined, the flank being the only exception. From these figures it is apparent that food values of beef cuts do not correspond to their wholesale market prices, and that the cheaper cuts are by far the most economical sources of both lean and fat meat. On the whole, the different cuts vary more widely in net cost of food ingredients than in market price per pound of gross meat. The following discussion tends to confirm these statements.

The manner of cutting and the location of the different retail cuts are shown in figure 2.

RETAIL CUTS.

Loin cuts.—Loin steaks averaged 59 per cent lean, 32 per cent visible fat, and 9 per cent bone. Sirloin steaks in general contained a greater proportion of lean and smaller proportion of fat than porterhouse and club steaks.

Rib cuts.—Rib roasts contained, on the average, 55 per cent lean, 30 per cent visible fat, and 15 per cent bone. The greatest percentage of lean was found in the sixth rib roast, and the smallest in the eleventh and twelfth rib cut.

Round cuts.—The various cuts made from the round averaged 65 per cent lean, 18 per cent visible fat, and 17 per cent bone. Round steaks contained 74 to 84 per cent lean, the rump roast 49 per cent, round pot roast 85 per cent, and soup bones 8 to 66 per cent. The maximum percentage of fat was found in the rump roast, and the maximum percentage of bone in the hock soup bone.

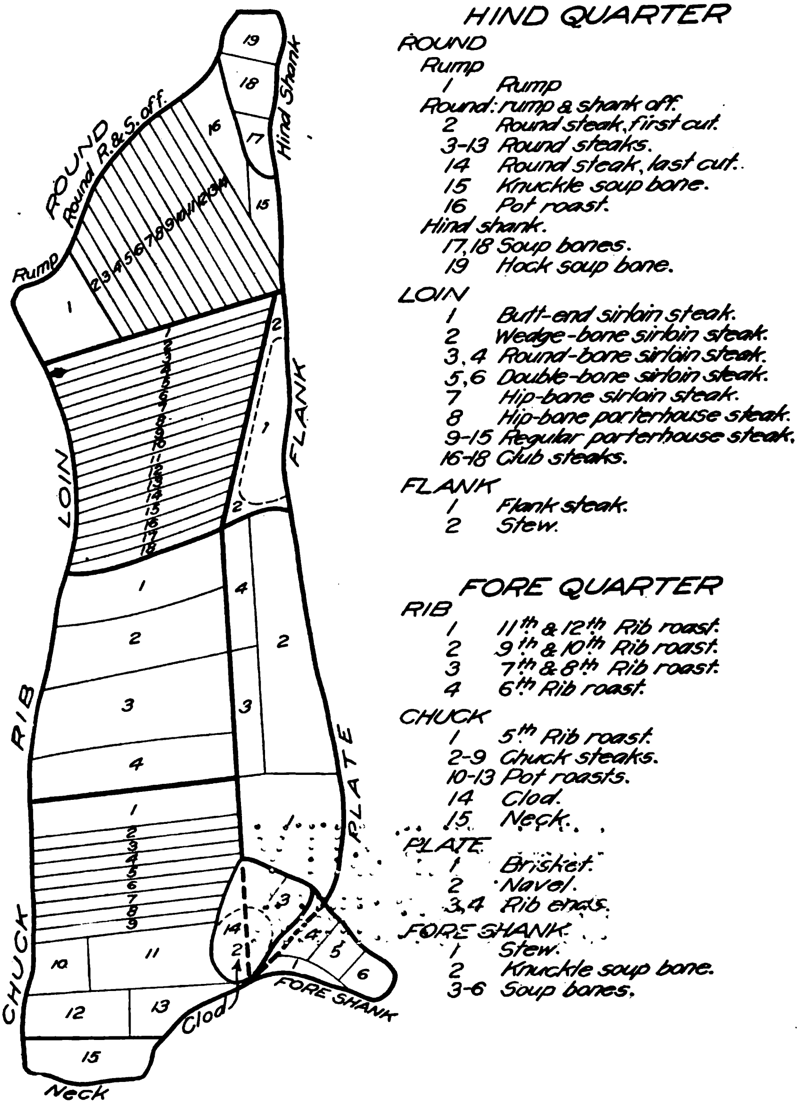

FIG. 2.—Retail cuts of beef.

Chuck cuts.—These contained an average of 69 per cent lean, 19 per cent fat, and 11 per cent bone. Chuck steaks varied from 62 to 82 per cent lean and from 6 to 22 per cent fat. The shoulder clod contained 80 per cent lean and only 5 per cent bone. Relatively more lean and less fat were found in the chuck rib roast than in those cut from the prime rib.

Plate cuts.—The brisket, navel, and rib ends averaged 51 per cent lean, 41 per cent fat, and 8 per cent bone. The brisket and navel were similar in proportions of the different constituents, but the rib ends were slightly higher in percentage of bone and lower in lean.

Flank cuts.—The flank steak contained 83 per cent lean and 16 per cent fat; and the flank stew, 64 per cent lean and 35 per cent fat,

Fore shank cuts.—Soup bones from the fore shank varied from 17 to 69 per cent lean and from 25 to 75 per cent bone. The boneless shank stew contained 83 per cent lean and 17 per cent visible fat.

Retail trimmings.—Trimming the loin steaks reduced their weight 12 per cent, and the trimmings were about four-fifths fat and one-fifth bone. Round and chuck steaks were reduced but 5 per cent in weight by trimming, only fat being taken from the former as a rule and principally bone from the latter. Other cuts that were materially affected by cutting off surplus fat and bone were the rump, shoulder pot roast, and neck.

RELATIVE ECONOMY OF THE VARIOUS RETAIL CUTS.

From the proportions of lean, fat, and bone in the different cuts, their relative economy at retail market prices may be determined. The net cost of lean meat is an approximate index of the relative economy of steaks and roasts, since they are purchased and used primarily for the lean they contain; but in comparing boiling, stewing, and similar meats the cost of gross meat, or fat and lean combined, should be more largely considered, because the fat is more completely utilized, as in the case of meat loaf, hash, Hamburger, and corned beef. Soup bones, being valued for flavoring matter as well as for the nutritive substance they contain, are more difficult to compare with other cuts in respect to relative economy. They vary materially, however, in proportions of edible meat and waste, and should therefore be studied in this connection.

The following table shows the cost of lean and of total meat in the various retail cuts at market prices:

Cost of lean and of total meat in the various retail cuts at market prices.

Retail cuts.	Diagram number (fig. 2).	Retail price per pound of cut.	Cost per pound of lean meat in cut.	Cost per pound of lean and fat meat in cut.
Steaks:		*Cents.*	*Cents.*	*Cents.*
Porterhouse, hip bone	8	25	38.6	28.9
Porterhouse, regular	10	25	40.2	27.2
Club steak	18	20	32.1	22.6
Sirloin, butt end	1	20	25.3	20.6
Sirloin, round bone	3	20	28.3	21.1
Sirloin, double bone	5	20	28.7	22.7
Sirloin, hip bone	7	20	32.3	24.2
Flank steak	1	16	19.3	16.0
Round, first cut	2	15	17.0	15.3
Round, middle cut	6	15	17.3	15.6
Round, last cut	14	15	19.3	16.0
Chuck, first cut	2	12	18.3	14.1
Chuck, last cut	9	12	15.7	13.1
Roasts:				
Prime ribs, first cut	1	20	40.5	22.9
Prime ribs, last cut	4	16	26.1	18.8
Chuck, fifth rib	1	15	22.8	17.3
Rump	1	12	19.4	12.8
Boiling and stewing pieces:				
Round pot roast	16	10	11.6	10.1
Shoulder clod	14	10	12.3	10.5
Shoulder pot roast	11	10	14.3	11.6

Cost of lean and of total meat in the various retail cuts at market prices—Con.

Retail cuts.	Diagram number (fig. 2).	Retail price per pound of cut.	Cost per pound of lean meat in cut.	Cost per pound of lean and fat meat in cut.
Boiling and stewing pieces—Continued.		*Cents.*	*Cents.*	*Cents.*
Rib ends	3	8	16.2	9.2
Brisket	1	8	15.0	8.7
Navel	2	7	12.8	7.7
Flank stew	2	7	10.9	7.1
Fore shank stew	1	7	8.5	7.0
Neck	15	6	8.5	7.0
Soup bones:				
Round, knuckle	2	5	26.3	12.5
Hind shank, middle cut	18	5	7.5	6.3
Hind shank, hock	19	5	62.5	26.6
Fore shank, knuckle	2	5	17.2	12.5
Fore shank, middle cut	4	5	12.5	9.4
Fore shank, end	6	5	28.8	20.9

Taking the net cost of the lean meat as a basis of comparison, we learn from these data that the most expensive steaks at the prices given are the porterhouse cuts, followed by the club, sirloin, flank, round, and chuck steaks. Of the different roasts, the first-cut prime ribs are the most costly in terms of lean meat, and the rump roast is the most economical. The various boiling and stewing pieces furnish lean meat more economically at market prices than either the roasts or steaks, the rib ends and brisket being the dearer cuts of this class, while the neck and shank stews are relatively cheapest. Several of the soup bones are very economical sources of lean meat, particularly the middle cuts of both shanks, and only one of them is extremely expensive even on this basis. In general the wide variation between the various cuts in net cost of lean is remarkable, ranging from 7.5 cents in one of the soup bones to 40.5 cents in a prime rib roast, and up to 62.5 cents in the hock soup bone, the latter, however, being used primarily for its flavoring substance rather than for lean meat. It will be observed, also, that the market prices of the cheaper cuts correspond much more closely to their net cost of lean meat than is true of the higher-priced steaks and roasts.

The net cost per pound of gross meat, or lean and fat combined, varies much less as between the different cuts than does the net cost per pound of lean, because the proportions of total meat are more nearly uniform than the percentages of lean. The various steaks and roasts rank in substantially the same order as to relative economy on this basis as on the basis of lean meat. The rib roasts, however, are considerably more economical as compared with the porterhouse and sirloin steaks when all the edible meat is considered. The rump shows a very low cost per pound of edible meat, due to the large proportion of fat it contains; and a still further difference is noticed in the case of the rib ends, brisket, navel, flank, neck, and several of the soup-bone cuts. The stewing meats are generally the most economical sources of edible meat at these prices, while porterhouse steaks are the most expensive.

On the whole, the data clearly show that the cheaper cuts of beef are by far the most economical sources both of lean and of total edible meat, including fat and lean. * * * No correlation exists between market prices and the proportion of flavoring substances contained in various portions of the carcass, and cooking tests indicate that the proportion of waste and shrinkage is not necessarily greater in the cheaper than in the more expensive cuts. It is evident, therefore, that retail prices of beef cuts are determined chiefly by considerations other than their food value, such as tenderness, grain, color, general appearance, and convenience of cooking. * * *

Relative economy.—There seems to be no relation between market prices and the percentages of fat, protein, extractives, and ash. The cheaper cuts appear to be as valuable and in some cases actually more so than the higher priced cuts from the standpoint of protein and of energy. These statements do not take into account the factors of tenderness nor the influence the degree of fatness may have upon the palatability of cooked meat. In purchasing meat for protein primarily, the neck, shanks, and clod are the most economical cuts; the plate, chuck, flank, and round follow; with the rump, rib, and loin as the most expensive. From the standpoint of fuel value, the flank, plate, neck, and shank cuts are the cheapest, while the rib, loin, and round are the most expensive. Considering both factors, protein and fuel value, and along with these the adaptability of the meat for general use the clod, chuck, and plate are the most economical cuts at the retail prices given.

TOBACCO DIPS FOR SHEEP SCAB.[1]

The Kentucky station, in cooperation with the Bureau of Animal Industry of this department, has made a series of experiments to determine "whether or not it is necessary to use sulphur with tobacco dips in the dipping of scabby sheep in order to effect a cure." The addition of sulphur increases the cost. "Therefore if the sulphur could be omitted and the dip still be effective, it would in the aggregate save a large sum of money yearly to the users of tobacco dips."

The results of these experiments, which were confirmed by those of subsequent dipping tests by the Bureau of Animal Industry on the western ranges under field conditions, indicated no benefit from the addition of sulphur to the nicotin solutions used (0.05 and 0.07 per cent nicotin).

SEWAGE DISPOSAL FOR RURAL HOMES.[2]

In modern sewage purification the process is partly mechanical and partly bacterial, consisting of preliminary or tank treatment and of final treatment which is the application to a natural soil by surface or subsurface distribution or to a specially prepared filter.

As stated by Prof. Anson Marston, of the Engineering Experiment Station at Ames, Iowa, the solid matter in sewage is allowed to settle out in a sewage tank and is there partially destroyed and liquefied by facultative and anaerobic bacteria, which also slightly affect the dissolved organic matter. The effluent from the tank is then filtered or allowed to pass through surface or subsurface distributing pipes in natural soil, in which processes the aerobic bacteria carry on the work of purification. To make conditions most favorable for bacterial action the sewage in the tank should be entirely at rest and light and air should be excluded, and since in the filters or distributing systems the aerobic bacteria must be supplied with air, it is necessary that the discharge of effluent from the tank be intermittent.

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[1] Compiled from Kentucky Sta. Bul. 157.

[2] Compiled from Iowa Engin. Sta. Bul. 6; Kansas Sta. Bul. 143; Missouri Engin. Sta. Bul. 3; Wisconsin Sta. Circ. 34; Bul. N. C. Bd. Health, 27 (1912), No. 4.

The investigations of C. A. Ocock and W. H. Wright, of the Agricultural Experiment Station at Madison, Wis., of W. C. Davidson, of the Engineering Experiment Station at Columbia, Mo., of Oscar Erf, of the Agricultural Experiment Station at Manhattan, Kans., and of W. H. Booker, of the North Carolina Board of Health, indicate that in the design of the settling compartment of a private septic tank a capacity should be allowed of from 5 to 15 cubic feet, or 40 to 80 gallons per person served, depending somewhat on the quantity of water used. Two compartments are necessary for satisfactory service, one for receiving the sewage, and in which sedimentation, bacterial action, and the liquefying process take place, and the other serving merely as a discharge chamber in which the automatic siphon is placed. The capacity of the settling chamber should approach the larger limit in order that it may hold from 24 to 36 hours of sewage. The discharge chamber should be of such capacity and the automatic siphon so adjusted as to cause a discharge about every 12 hours. In arranging this accurate data should be obtained from manufacturers of automatic siphons regarding the adjustment, discharge depths, and discharge capacities of siphons in order that the discharge chamber be built at the proper depth and capacity to discharge the required quantity at the stated intervals. The tank should be constructed as nearly water-tight as possible, preferably of concrete, and some means should be provided at the bottom to facilitate the cleaning out of the settled sludge. The inlet should be provided with an elbow so as to discharge below the water line and the escape pipe in the partition wall should be arranged in the same way. Where the flow is very strong baffle boards or walls should be arranged before these openings to retard the current. The tank should be at least 175 feet away from the house, and the sewer from house to tank should be of vitrified sewer pipe with carefully cemented joints and laid to a grade of not less than 1 foot in 100 feet.

Figure 3 is a design of a septic tank submitted by W. C. Davidson, of the Missouri Engineering Experiment Station, which is large enough to provide for the sewage disposal of a family of six. This tank is suited to conditions where plenty of fall is available for the outlet.

The bill of material for the above septic tank is as follows:

Cement, 22 sacks.
175 feet 4-inch vitrified clay pipe for the sewer from house to tank and for outlet.
10 feet 3-inch vitrified clay pipe.
Automatic siphon.

The necessary sand and gravel can usually be obtained from nearby creeks. When the excavation is made the outside wall may be used for the outside form for the concrete.

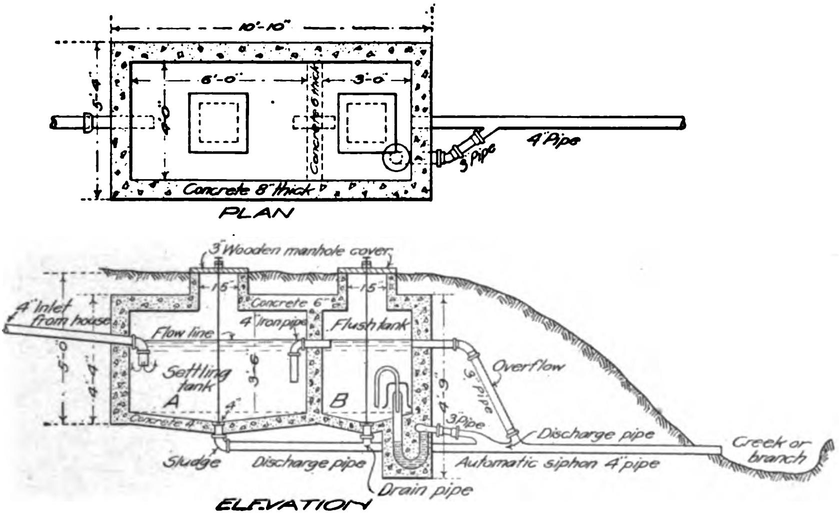

FIG. 3.—Small concrete septic tank.

Figure 4 is a design of a septic tank submitted by Messrs. Ocock

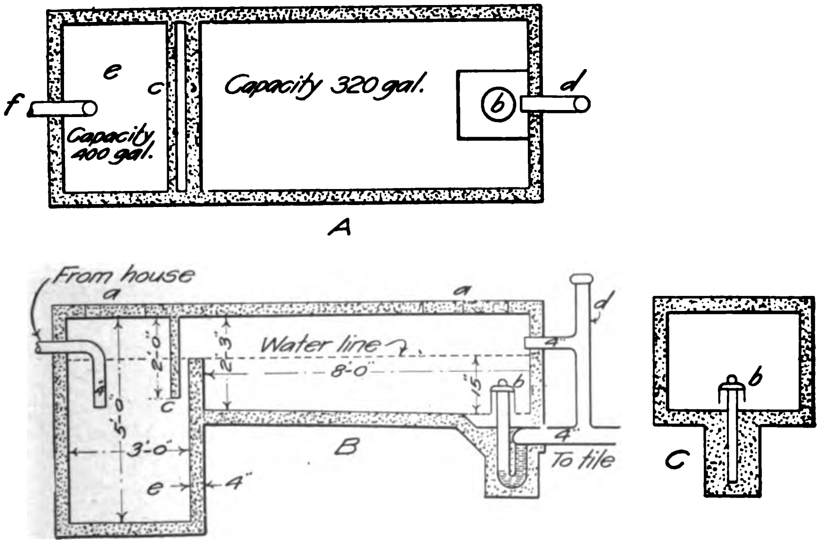

FIG. 4.—Double-chamber tank for a seven-room house.

and Wright which is suitable for a family of about six. It will be noted that the floor of the discharge chamber in this design is considerably above the floor of the settling chamber. This design is particularly suited to flat ground where outlet fall is difficult to obtain.

The bill of material for this septic tank is as follows:

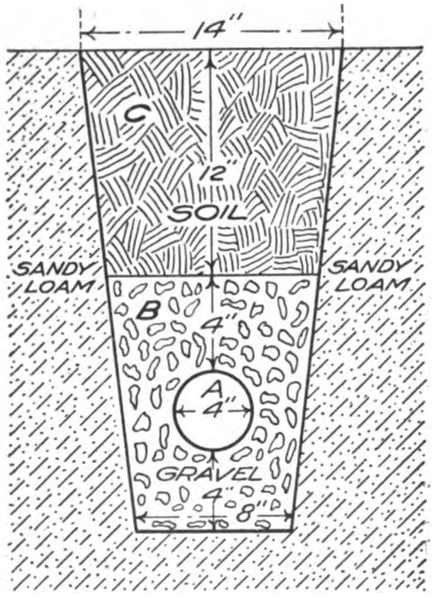

FIG. 5.—Cross-section of a single-tile system.

Cement, 5.5 barrels.
Sand, 2 cubic yards.
Gravel, 3 cubic yards.
Reenforcing steel.
Iron pipe for vent.
Automatic siphon.

The proportions of the concrete in these tanks may vary from 1 part cement, 2 parts sand and 4 parts gravel, to 1 part cement to 2 parts sand to 6 parts gravel.

The disposal system for subsurface distribution of the tank effluent is described by Messrs. Ocock and Wright as follows: The system consists of tile so laid that the liquid sewage is quickly absorbed by the soil when intermittently discharged from the tank. The disposal tile as shown in figure 5 should be placed in the ground not deeper than 14 inches to 16 inches from the surface of the soil tó the top of the tile. Aeration of heavy soils can be brought about by the use of coarse cinders or gravel laid in 12-inch to 16-inch layers in the bottom of the tile ditch, with the top about 12 inches below the surface. The disposal tile

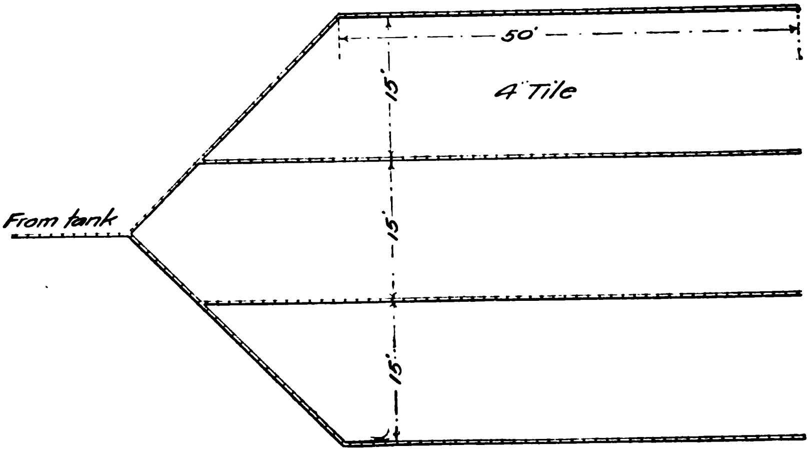

FIG. 6.—Ground plan of absorption system.

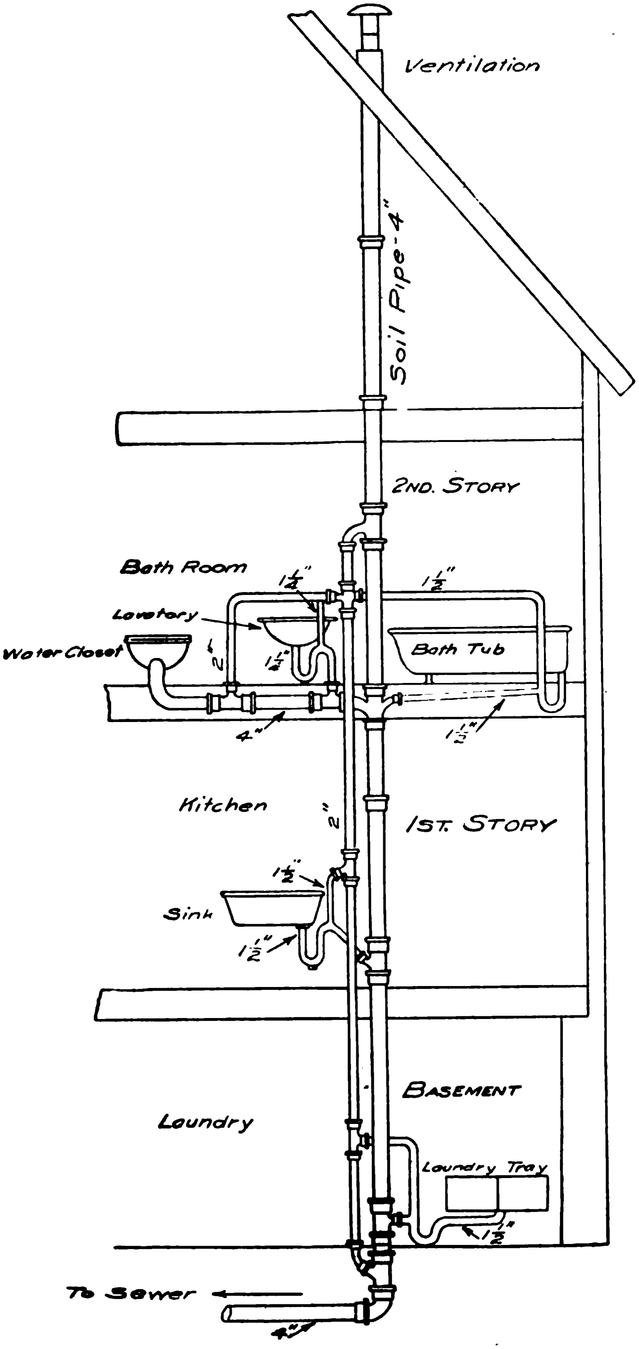

FIG. 7.—Plumbing system for sewage disposal.

should have a fall not to exceed 1 inch in 50 feet, else the water will all rush to the lower end, and in a short time the soil will become waterlogged there. The tile used are the ordinary 4-inch drain tile, laid about one-fourth inch apart. One foot of tile should be provided for every gallon of water discharged into the system, but for heavy soils 2 feet of tile per gallon should be provided to give the best results. Figure 6 shows the ground plan of such a system. About 325 to 400 tile are required with gravel and cinders for a family of six.

The house plumbing should be carefully done, and an experienced plumber should be employed for this work. Figure 7 is a design for the house sewer plumbing submitted by W. C. Davidson of the Missouri Engineering Experiment Station.

The prices for materials will vary in different localities.

A1.9:528 a.1,8,6,7.

Issued April 12, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 528.

HINTS TO POULTRY RAISERS.

BY

HARRY M. LAMON,

Senior Animal Husbandman in Poultry Investigations,
Animal Husbandry Division, Bureau of Animal Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., January 30, 1913.

Sir: I have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, a paper entitled "Hints to Poultry Raisers," prepared by Mr. Harry M. Lamon, senior animal husbandman in poultry investigations in the Animal Husbandry Division of this bureau, under the direction of Mr. George M. Rommel, chief of that division. This paper is a revision of Circular 206 of this bureau.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

80651°—Bull. 528——13.

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HINTS TO POULTRY RAISERS.

SELECTION OF A BREED.

Be sure that the male at the head of the flock is purebred.

The Mediterranean or egg breeds are: Leghorns, Minorcas, Spanish, Blue Andalusians, and Anconas.

The American or general-purpose breeds are: Plymouth Rocks, Wyandottes, Javas, Dominiques, Rhode Island Reds, and Buckeyes.

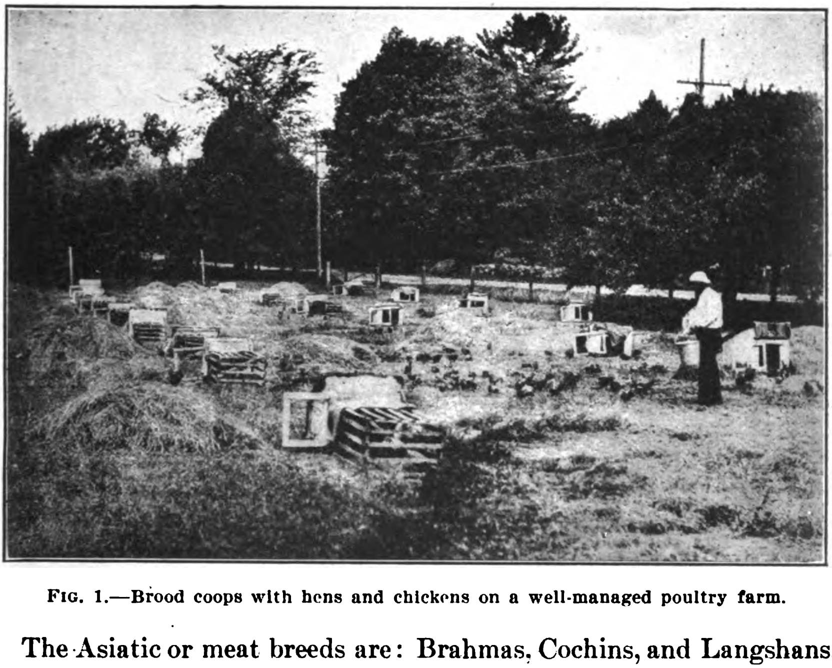


FIG. 1.—Brood coops with hens and chickens on a well-managed poultry farm.

The Asiatic or meat breeds are: Brahmas, Cochins, and Langshans.

The English breeds are: Dorkings, Orpingtons, and Redcaps.

For farm use the American breeds are probably the best.

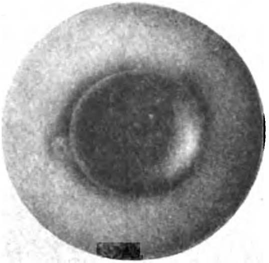
Purebred poultry means uniformity of products.

Uniformity of products means increased profits, if products are properly marketed.

Given the same care and feed, purebred fowls will make a greater profit than mongrels.

ATTENTION ❊ FARMERS

PRODUCE INFERTILE EGGS
PREVENT LOSS FROM BAD EGGS

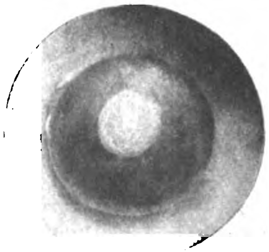

1. Fresh egg.

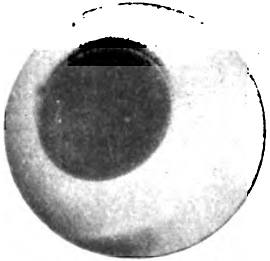
The loss to the farmers of the United States from bad methods of producing and handling eggs is estimated at $45,000,000 annually.

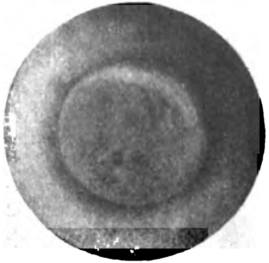
IT IS ALSO ESTIMATED THAT $15,000,000 OF THIS LOSS IS DUE TO BLOOD RINGS.

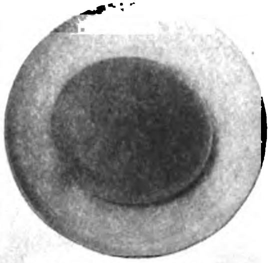
Every dollar of this loss from blood rings is directly preventable on the farm.

Blood rings are a certain stage of

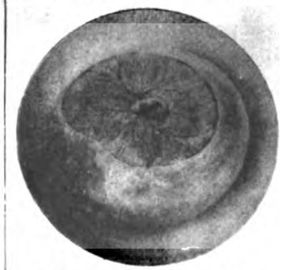

2. Fertile egg after 24 hours of incubation.


3. Infertile egg after 24 hours of incubation

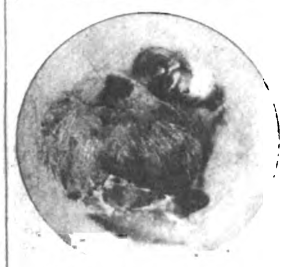

4. Fertile egg after 36 hours of incubation.


5. Infertile egg after 36 hours of incubation.

6. Fertile egg after 48 hours of incubation.



8. Fertile egg after 72 hours of incubation



10. Fertile egg after 7 days of incubation

Figures 4, 6, and 8.)

Blood rings often develop in the nest and in an unheated room in the house during the hot summer weather. (See Figures 4, 6, and 8.)

Blood rings can not be produced in the infertile egg.

Blood rings are troublesome only in hot weather.

Infertile eggs are eggs laid by hens that are not allowed to run with a male bird. (See Rule 5, below.)

A study of these pictures should quickly convince one that the infertile egg is the quality egg; therefore, produce it, by removing the male birds from the flock, and realize more money for better eggs. The removal of the male birds has absolutely no influence on the egg production.

RULES

Farmers are urged to adhere strictly to the following rules in handling their poultry and eggs:

1. Keep the nests clean, provide one nest for every four hens.
2. Gather the eggs twice daily.
3. Keep the eggs in a cool, dry room or cellar.
4. Market the eggs at least twice a week.
5. Sell, kill, or confine all male birds as soon as the hatching season is over.

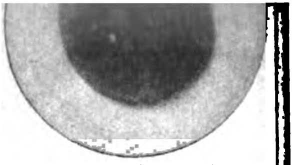
NOTICE

Information on the care of poultry and eggs may be had by writing to the Bureau of Animal Industry, U. S. Department of Agriculture, Washington D. C.

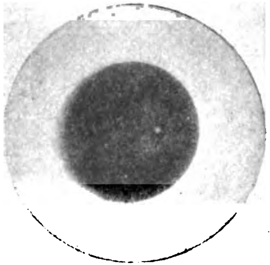
A. D. MELVIN,
Chief Bureau of Animal Industry.

Approved:
JAMES WILSON,
Secretary.

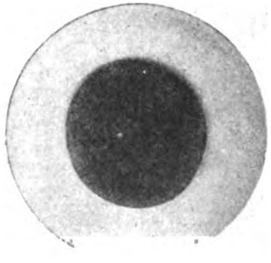
Washington, D. C., July 10, 1912.



7. Infertile egg after 48 hours of incubation.



9. Infertile egg after 72 hours of incubation.



11. Infertile egg after 7 days of incubation.

FIG. 2.—Copy of a poster prepared by the Bureau of Animal Industry to be displayed in public places. It is inserted here to show graphically the enormous loss in the annual value of our egg crop due to blood rings. These are traceable directly to improper methods of management on the farm, but may be readily and simply prevented at little or no expense.

80651°—Bull. 528—13——pp. 6 and 7.

Subscribe for a good poultry paper.

Every poultry keeper should have a copy of the American Standard of Perfection.[1]

ARTIFICIAL AND NATURAL INCUBATION AND BROODING.

Have everything ready beforehand and start your hatching operations early in the year.

A well-ventilated cellar is the best place to operate the incubator.

The machine should be operated according to the manufacturer's directions.

See that the incubator is running steadily at the desired temperature before filling it with eggs. Do not add eggs to a machine during incubation.

Turn the eggs twice daily after the second and through the eighteenth day. Cool the eggs once daily, according to the weather, from the seventh through the eighteenth day.

Turn the eggs before caring for the lamp.

Attend to the machine carefully at regular hours.

Keep the lamp and wick clean.

Test the eggs on the seventh and fourteenth days.

Do not open the machine after the eighteenth day until the chickens are hatched.

Eggs saved for hatching purposes should not be subjected to high or low temperatures.

In cold weather place from 10 to 13 eggs under the hen; in warm weather from 13 to 15.

Always test the hen on china or nest eggs before setting.

Given proper care and attention, the hen is the most valuable incubator for the farmer.

Use insect powder freely to exterminate lice when necessary.

February, March, and April are the best months for hatching.

If several hens are set in one room, it is desirable to confine them in good nests.

Straw and hay make good nesting material.

Broody hens should be moved to the permanent sitting nest at night.

Whole corn is a good feed for sitting hens. Water, grit, and dust baths should also be provided.

All eggs should be tested by the seventh day, which often makes it possible to reset some of the hens.

---

[1] This is the official standard of the American Poultry Association and may be obtained from the secretary, Mr. S. T. Campbell, Mansfield, Ohio.

Toe-mark the chicks as soon as they are hatched. This enables one to tell their ages later.

Powder the chicks occasionally during the first eight weeks.

Start the brooder a day or two before putting in the chicks to see that the heating apparatus is working properly.

Brooder lamps should be cleaned every day.

A record should be kept of each hatch, showing the date set, number and kind of eggs, number tested out, and the chickens hatched.

Chicks should not receive feed until they are 36 hours old.

In cool weather 10 to 13 chicks are sufficient for one hen, while in warmer weather 15 to 20 can be cared for successfully.

Never mix chicks of different ages.

Confine the hen until the chicks are weaned.

The coop for hen and chicks should be well ventilated, easy to clean, and of sufficient proportions to insure comfort.

The early hatched pullet is the one that begins to lay early in the fall, when eggs are high in price.

The cockerel that can be marketed as a broiler in March or April brings more money than the one marketed in June.

POULTRY HOUSES AND FIXTURES.

Select a location that has natural drainage away from the building.

A dry, porous soil, such as sand or gravelly loam, is preferable to a clay soil.

In most localities the building should face the south, as this insures the greatest amount of sunlight during the winter.

Allow at least 2 square feet of floor space per bird.

Proper ventilation and sunlight mean a dry house and healthy birds.

The partial open-front house is conceded to be the best type for most sections.

The colony plan of housing poultry may be adopted to good advantage on many farms. This system does away with the danger of tainted soil.

The roosts should be built on the same level, 2 feet 6 inches from the floor, with a dropping board about 8 inches below them.

Good roosts may be made of 2 by 2 inch material with upper edges rounded.

The nests may be placed on the side walls or under the dropping boards. It is best to have them darkened, as the hens prefer a secluded place in which to lay.

FEEDING.

In order to obtain eggs it is necessary to have healthy, vigorous stock, properly fed.

Nature provides—	Scientific classification.	Poultrymen feed—
Worms and bugs	Nitrogenous material or protein	Eggs, meat (green cut bone or beef scrap), milk, or cottage cheese.
Seeds	Nonnitrogenous	Wheat, oats, corn, barley, etc.
Greens	Succulents	Lettuce, cabbage, kale, mangels, alfalfa, clover, sprouted oats, etc.
Grit	Mineral matter	Grit and oyster shell.
Water	Water	Water.

A splendid mixture for laying hens is equal parts of cracked corn, wheat, and oats, which should be scattered in the litter.

Bran or middlings and beef scraps should be kept in receptacles to which the fowls have access at all times.

Plenty of exercise increases the egg yield.

Provide 4 or 5 inches of good, clean litter in which to scatter the grain.

Cabbages, mangels, potatoes, sprouted oats, etc., make excellent green feed.

When wet mashes are fed, be sure they are crumbly and not sticky.

For the first three days chicks may be fed a mixture of equal parts hard-boiled eggs and stale bread, or stale bread soaked in milk. When bread and milk are used, care should be exercised to squeeze all milk out of the bread. From the third or fourth day until the chicks can eat wheat and cracked corn, commercial chick feed is a good ration.

Plenty of pure, fresh water, grit, shell, and green feed should be available from the first day.

There is very little danger of overfeeding young stock.

Feed the chickens about five times daily and only what they will eat up clean in a few minutes, except at night, when they should receive all they want.

EGG PRODUCTION.

Produce the infertile egg. (See Rule 5, last page.)

Infertile eggs are produced by hens having no male birds with them.

Removing the male bird has no influence on the number of eggs laid by the hens.

The hen's greatest profit-producing period is the first and second years, and unless a hen is an exceptionally good breeder she should be disposed of at the end of her second laying season and before starting to molt.

Few eggs can be expected until the pullets are matured.

If possible, mark the pullets that lay in the fall, and use them in the breeding pen for the following spring.

Soft-shelled eggs are often caused by fowls being confined, becoming overfat, and from lack of mineral matter.

MARKETING.

Uniform products command the best prices. Purebred fowls produce uniform products.

Begin marketing the cockerels as soon as they weigh 1½ pounds or attain a marketable weight.

Market white-shelled and brown-shelled eggs in separate packages.

When selling eggs to the country merchant or cash buyer, insist that the transaction be on a quality basis.

Ship or deliver eggs twice or three times weekly.

Small or dirty eggs should be used at home.

When taking eggs to market they should be protected from the sun's rays.

Infertile eggs will withstand marketing conditions much better than fertile eggs.

LICE AND MITES.

The free use of an effective lice powder is always in order.

A dust bath is very essential in ridding the fowls of lice.

In applying powder hold the fowl by the feet, head down, and work the powder well down into the feathers.

The free use of kerosene on the roosts and in the cracks will exterminate mites.

Whitewash is very effective against vermin.

COMMON DISEASES AND TREATMENT.

All diseased birds should be isolated.

Colds and roup.—Disinfect the drinking water as follows: To each gallon of water add the amount of potassium permanganate that will remain on the surface of a dime.

Canker.—Sprinkle a little flowers of sulphur in the mouth and throat of the bird, and put some chlorate of potash in the water. Also carefully remove the exudate with the aid of warm water and apply a 2 per cent solution of creolin to the diseased tissue.

Chicken pox.—Apply a touch of iodin and carbolated vaseline to each sore.

Gapes.—New ground and vigorous cultivation will often remedy this trouble.

Scaly legs.—Apply vaseline containing 2 per cent of creolin to the affected parts, and after 24 hours soak in warm soapy water. Repeat treatment until cured.

Diarrhea in hens.—Low-grade wheat flour or middlings is good for this trouble. Also give teaspoonful of castor oil containing five drops of oil of turpentine to each fowl.

Bowel trouble in chicks.—Well-boiled rice mixed with a little charcoal will often check this complaint. Dissolve 15 grains of crude catechu in each gallon of drinking water.

RULES.

It is urged that all farmers and poultrymen adhere strictly to the following rules in handling their poultry and eggs:

1. Keep the nests clean; provide one nest for every four hens.
2. Gather the eggs twice daily.
3. Keep the eggs in a cool, dry room or cellar.
4. Market the eggs at least twice a week.
5. Sell, kill, or confine all male birds as soon as the hatching season is over.

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A 1.9: 529

Issued May 17, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 529.

VETCH GROWING IN THE SOUTH ATLANTIC STATES.

UNIVERSITY OF VIRGINIA
GENERAL LIBRARY
1819

BY

A. G. SMITH,
Agriculturist, Office of Farm Management,
Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., March 8, 1913.

Sir: I have the honor to transmit herewith a paper entitled "Vetch Growing in the South Atlantic States," by Mr. A. G. Smith, Agriculturist, Office of Farm Management, of this Bureau. This manuscript was prepared by Mr. Smith under special arrangement with the Office of Forage-Crop Investigations.

The use of vetch is rapidly increasing in these States, and it is to encourage the proper use of this crop and to furnish information to the farmers of this great district in particular that the data here given are submitted.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. D. F. Houston,
Secretary of Agriculture.

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B. P. I.—844.

VETCH GROWING IN THE SOUTH ATLANTIC STATES.

INTRODUCTION.

Vetch is grown on practically every type of soil in North Carolina, South Carolina, and Georgia. Nearly all the plantings are small, as most growers have just begun to plant vetch, but on some farms where it has become well established 50 acres or more are planted annually. In the fall of 1911 approximately 1,000 plantings were made in South Carolina alone. Lack of knowledge of the proper cultural methods caused many failures, but where the principles involved in vetch growing were followed successful results were obtained.

Vetch should occupy an important place in the agriculture of these States. In four years' comparisons on over 800 fields, vetch, more particularly hairy vetch, has consistently made heavier growths and greater yields than crimson clover, red clover, or bur clover, although under favorable conditions these have done well. Vetch is high in protein content, is a good hay, pasture, and soiling crop, and its more general growth would aid in the development of the live-stock industry and remove much of the existing necessity for buying hay outside the State. Vetch is used as a cover crop to prevent the leaching and washing of soils. Like all legumes, it improves land by adding nitrogen and organic matter to the soil. As it grows through the winter and spring and may be harvested in time to plant corn, cowpeas, and sometimes cotton on the same land, it should be used in building up impoverished soils and in maintaining the productivity of the land.

The vetch crop does not require horse or man labor at any time when this is needed for the cowpea crop, except possibly at the harvest time of cowpea hay.

KINDS OF VETCH CULTIVATED IN THE SOUTH ATLANTIC STATES.

There are many kinds of vetch, but only three are cultivated to any extent in the South Atlantic States. These are the so-called "native" vetch, but more properly called narrow-leaved vetch

(*Vicia angustifolia*), since it is not native but is an introduced species that has become wild; English, Oregon, or common vetch (*Vicia sativa*); and hairy or sand vetch (*Vicia villosa*).

The "native" or narrow-leaved vetch is found growing wild by roadsides, in waste places, and frequently in meadows and pastures. It is not grown to any extent in plowed fields. It grows erect when the plants are close together, is hardy, and matures earlier than the other varieties, ordinarily ripening seed from April 15 to May 10 in South Carolina, although in early seasons some seed may be ripe by the last of March. It does not grow so large as the other varieties, although when planted thick it makes heavy yields. When ripe the pods burst open and scatter the seed.

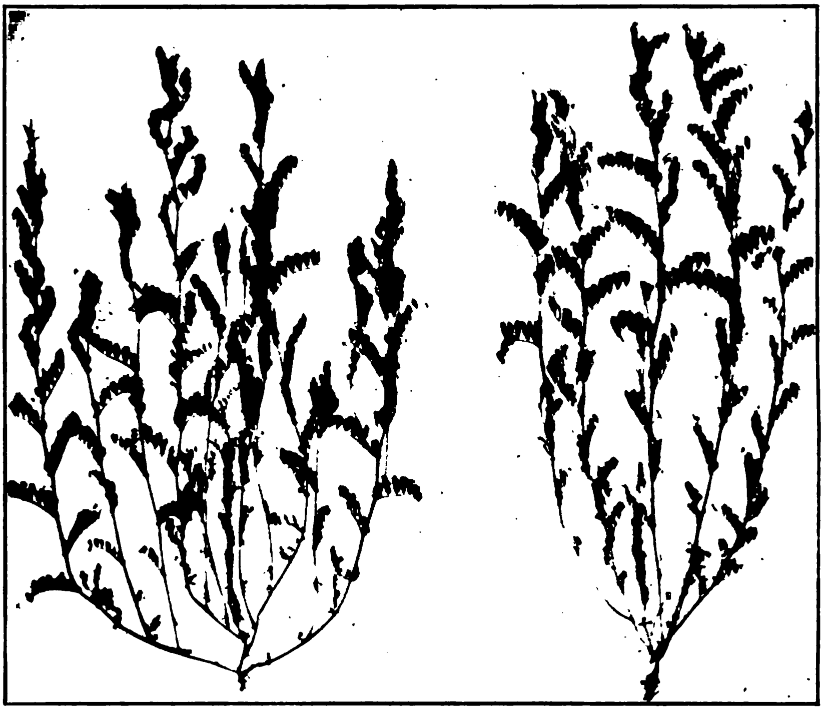

FIG. 1.—Plants of English, Oregon, or common vetch (*Vicia sativa*).

Common vetch (fig. 1) grows erect where the plants are close together and ordinarily has from three to five stalks to the plant. It resembles the narrow-leaved vetch, but grows larger and does not shed its seed so readily. It is also later in maturing, ripening seed from May 10 to May 25 in South Carolina. It is not so hardy as either the narrow-leaved or hairy vetch, being subject to winter-killing at temperatures lower than 15° F. It does not do well on light lands or in dry seasons, the best results being obtained on loamy soils with a moderate rainfall. Where conditions are favorable, it yields as large crops as hairy vetch and is much more easily handled.

Hairy vetch, or sand vetch (fig. 2), has a much more recumbent or reclining growth than common vetch. Unless sown with some other crop to give it support, it falls down and is more or less difficult to harvest. Each stalk produces from 5 to 100 branches (the number depending on the opportunity given the plant), frequently from 6 to 9 feet long. It usually matures from May 20 to June 10 in the latitude of South Carolina. The first pods near the ground ripen while the top of the plant is still in bloom. Hairy vetch is very hardy and never winterkills in the South Atlantic States when properly handled. Heavy yields have been made on all types of soil. The name "sand vetch" is applied to it on account of its ability to do well on sandy soil. It is hardier than common vetch, and when planted side by side with it on land that has never previously grown vetch it frequently makes a heavy growth when common vetch is a complete failure (fig. 3). For this reason hairy vetch should be grown on the land before attempting to grow common vetch. Many failures have been made by using common vetch on land that should have been planted with hairy vetch. When the

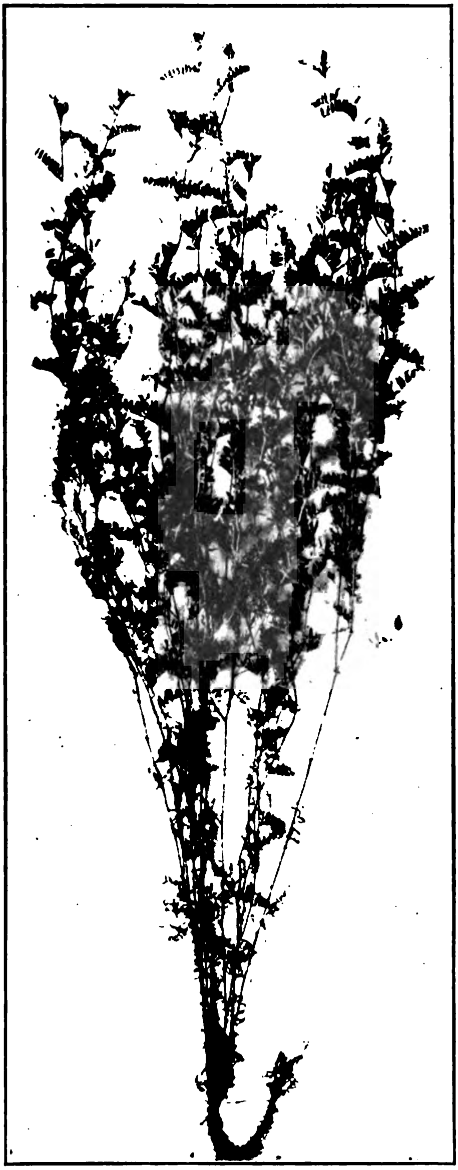

Fig. 2.—A plant of hairy, winter, or sand vetch (*Vicia villosa*).

land is suitable, well inoculated, and fairly fertile, common vetch does well, and because it is earlier, more easily handled, and less expensive in seeding it is preferred to hairy vetch, but for general purposes it is not so successful.

FERTILIZING VALUE OF VETCH.

The greatest value of vetch lies in its fertilizing powers, due to the fact that, like other legumes, it is able to use the free nitrogen of the air through the aid of bacteria which live in the nodules on the roots. When plowed under, the plants decay quickly. A ton of hairy-vetch hay contains about 50 pounds of nitrogen, while the roots and stubble, including the nodules, contain approximately one-fourth as much more. This makes a total yield of 62.5 pounds (from one-fourth to three-fourths of which probably comes from the air), which is equal to the nitrogen in 417 pounds of nitrate of soda. This, at $48 per ton, is worth $10. Besides nitrogen, vetch furnishes organic matter which is valuable in improving the physical condition of the soil and in making available the mineral elements of plant food in the soil.

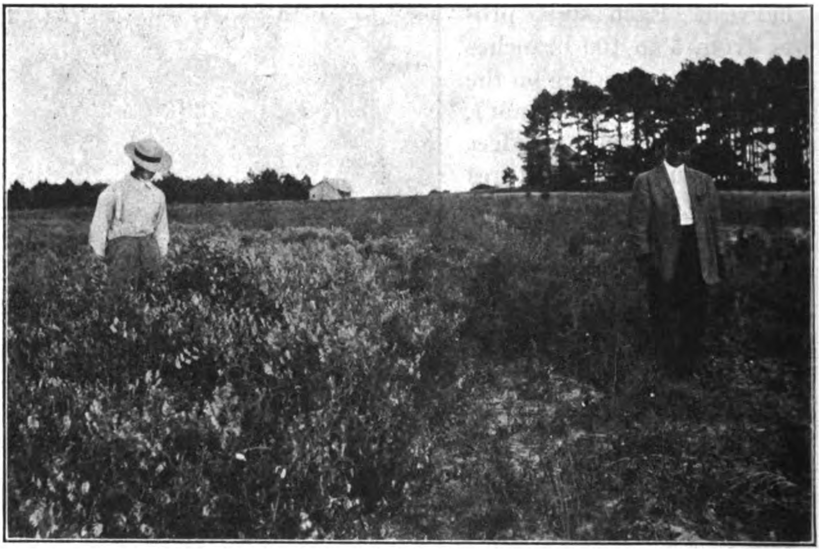

FIG. 3.—Field showing hairy vetch with oats (at the left) and common vetch alone (at the right), sown on clay land for the first time, indicating the superior hardiness of hairy vetch.

Vetch will increase the growth of a following crop of cowpeas more than a crop of cowpeas will increase a crop of vetch. Observation of the results and the percentage of nitrogen in the two plants indicate that vetch is superior to cowpeas in building up the productiveness of the land. A ton of cowpea hay contains approximately only four-fifths as much nitrogen as a ton of vetch hay.

TIME FOR PLANTING VETCH.

The fact that vetch if not harvested will reseed itself, the seed lying on the ground after maturing in the spring and coming up in the fall, shows that the season of planting extends over a long period. Vetch may be planted at any time from August until December, inclusive, but the best results are obtained by planting from August 15 to October 15. In years when the seasons are favorable, especially when the land is fertile and well inoculated, late planting may do well, but as a rule there is considerable risk in seeding after October 15. If the vetch gets well started and is inoculated there is little danger from any hot or dry weather that may occur in the fall, but it should have time to become firmly rooted before cold weather sets in. Late fall-planted vetch suffers from dry weather in the spring much more than the earlier fall-planted and better rooted vetch. In the spring of 1910 and 1911 there were many failures in South Carolina with vetch planted as late as December 1 because it failed to get sufficient root growth to withstand the spring droughts. In the winter of 1911 and 1912 much of the late-planted vetch was killed by the cold weather before it got well started.

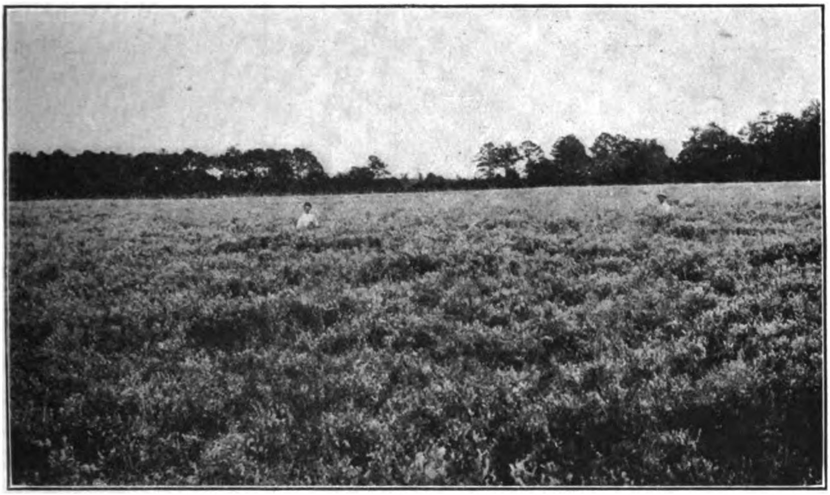

FIG. 4.—Field showing hairy vetch planted in cotton after the first picking. Yield, 1,000 pounds of seed cotton and 1½ tons of hairy vetch.

Vetch may be planted in cotton when it is laid by or after the first or second picking. Figure 4 shows a field in Newberry County, S. C., of vetch planted in cotton after the first picking in September. This cotton yielded 1,000 pounds of seed cotton and the vetch yielded approximately 1½ tons of hay to the acre.

QUANTITY OF SEED REQUIRED.

Inasmuch as narrow-leaved vetch seed is difficult to obtain and is not commonly sown, nothing definite as to the quantity of seed required has been determined. As the seeds are small, 25 pounds per acre are probably sufficient. With common vetch 45 pounds are used by the best growers. In order to facilitate the harvesting of the hay, it is customary to sow from one-half bushel to a bushel of oats per acre with the common vetch. Thirty pounds of good hairy vetch seed and from 1 to 2 bushels of oats per acre are usually sown. Where hairy vetch has been grown previously, 20 to 25 pounds of vetch seed and 2 bushels of oats, handled properly, will give good yields on fertile soils.

If vetch is used for soiling, from 50 to 80 per cent more seed should be sown than when planted for hay. If used as a winter cover crop, smaller quantities will give good results.

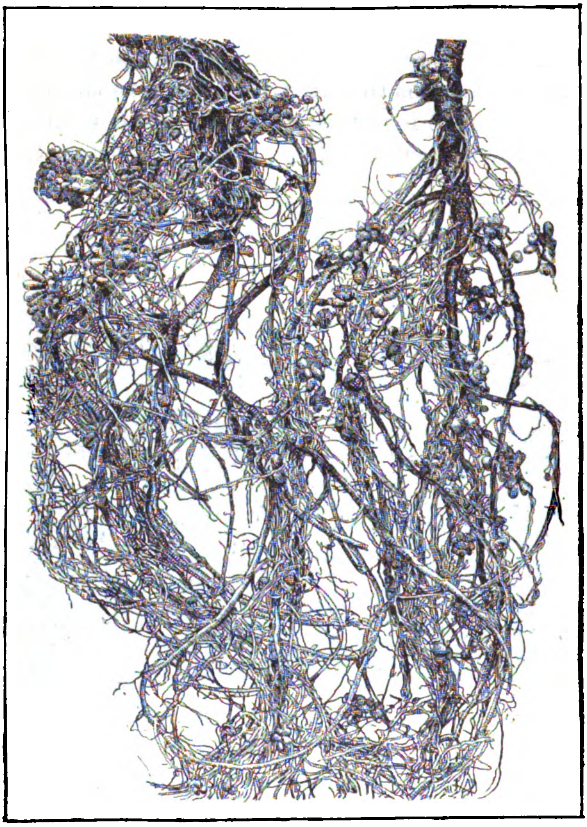

FIG. 5.—Roots of hairy vetch, showing nodules.

The seed should be tested before planting and the quantity of seed sown per acre regulated accordingly because of the variability in the germination of vetch seed. This variability is due partly to the unevenness of the ripening of the vetch seed and partly to the fact that some of the seed must necessarily be harvested in an immature state.

INOCULATION OF VETCH.

On land that has never grown vetch, the best results are obtained by inoculation. The nitrogen-gathering bacteria, which take nitrogen from the air, must be present in the soil before a satisfactory growth can be made. The presence of the bacteria is indicated by the nodules on the roots of the vetch plants, as shown in figure 5. A part of the nitrogen producèd by these bacteria is used by the plant and the remainder goes into the soil when the nodules decay. Without nitrogen-gathering bacteria the vetch plants come up in the fall, but turn red and die or make a poor growth the succeeding spring.

In some communities where narrow-leaved vetch is found growing wild there are occasionally enough bacteria already in the soil to produce good results, but this is rarely the case. Bottom lands subject to overflow are usually well inoculated for vetch, but, unless it is positively known that the necessary bacteria are present, the vetch should be inoculated.

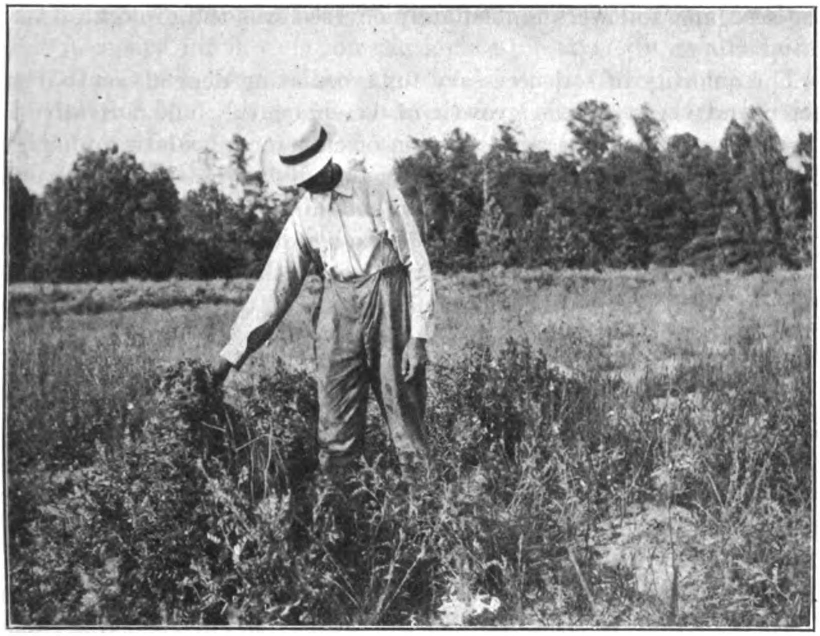

FIG. 6.—Field showing the result of the proper inoculation of vetch. The inoculating soil was covered as soon as applied. In the rows where no vetch is seen the inoculating soil was exposed to the sun for an hour.

There are two principal ways of inoculation: (1) By the use of artificial vetch culture, such as is distributed by the United States Department of Agriculture; and (2) by using soil from a field where vetch has recently grown thriftily. The second method has proved more uniformly successful. Soil from spots where narrow-leaved vetch has grown will inoculate for all kinds of vetch. Special care should be taken to avoid using soil that contains noxious weeds or is infested with plant diseases. Soil for inoculation can be used to a depth of 6 or 8 inches. It should be protected from the sunlight as much as possible while it is being transferred from one field to another and should be worked in with a harrow or drag as soon as applied. As the direct rays of the sun kill the bacteria, better results are usually obtained if this transfer is made on a cloudy day, early in the morning or late in the evening.

Figure 6 shows a plat of vetch planted in cotton with a guano distributor. The seed and inoculating soil were put down together and covered immediately. On the adjoining plat the inoculating soil was sown and left exposed to the sun for an hour. Only where the seed and soil were immediately covered was the growth of vetch satisfactory.

The quantity of soil necessary for inoculating depends on its character and the previous growth of vetch on the land. Sandy soil does not seem to be as good as loam or clay for inoculating purposes. Soil containing a good supply of organic matter is best, as it usually contains the most bacteria. No soil should be used unless the growth of vetch on it has been luxuriant. Two hundred pounds of the proper kind of soil may be sufficient for 1 acre, although the chances of success are better with larger quantities. If the soil is convenient, 1 ton per acre should be used.

Basic slag can be mixed with inoculated soil and sown with vetch seed and oats with good results, using either a guano distributor or a combination wheat and fertilizer drill. In order to facilitate handling the soil in this way it should be run through a sieve. A common sand screen can be used for this purpose. Acid phosphate kills bacteria when they come in contact with it, and when used it should be applied several days before or the spring before the inoculation is attempted, either with soil or artificial culture. Where vetch is planted for the first time, basic slag has given better results than acid phosphate with both kinds of inoculation. At Pelzer, S. C., vetch planted on fertile clay soil had better inoculation and made a heavier growth with basic slag than with acid phosphate.

An application of lime assists in securing inoculation on acid soils, although on most soils of the South Atlantic States, even though lime is beneficial, vetch succeeds well without liming. Barnyard manure aids in making the inoculation more complete, but is not a substitute for inoculation. However, manure made from vetch hay may contain sufficient bacteria, so that when applied to the land no further inoculation is necessary.

Vetch seed carry some nodule-forming bacteria on their surface, and some growers have obtained fair success in inoculating land by sowing 2 quarts of vetch seed with winter oats year after year until the soil becomes inoculated. Ordinarily this is not a good method, as it takes too long to obtain the maximum results. A good plan for any one just beginning vetch growing is to prepare thoroughly half an acre of fertile land, use plenty of barnyard manure, and inoculate the soil. Forty pounds of hairy vetch seed and 1 bushel of oats should be sown to the acre. This should make a good stand of vetch, and if the soil for inoculation has been carefully handled there should be an abundance of nodules on the vetch roots. The next year soil from this half acre can be used for inoculating larger fields and the farmer can extend his area of vetch as he sees fit. If the vetch does not become well inoculated the first year, it should be planted again on the same land until the inoculation is complete.

The necessity for inoculation can not be too strongly emphasized; more failures have been made with vetch in South Carolina from lack of inoculation than from any other cause. One cooperator reported on this point as follows: "On a 5-acre plat where soil was used from an inoculated field, the crop was a decided success. On a 7-acre field where no inoculation was used, the crop was a complete failure," After a field has once grown vetch successfully, however, it will require no more inoculation, unless it is not reseeded in vetch for several years.

PRODUCTION OF VETCH HAY.

Vetch is used for hay more than for any other purpose. At Augusta, Ga., where hay made from vetch and oats is well known, it sells on a par with cowpea hay. Liverymen buy it extensively, and it is shipped in considerable quantities to the sawmills and lumber camps of Florida. From 1 to 3 tons to the acre are common yields, which, at prices varying from $15 to $20 a ton, make it a profitable crop. Vetch makes the best hay if cut when the first pods appear or before the stems and lower leaves are damaged. If cut later, the yield will be greater but the quality will not be so good.

Narrow-leaved and common vetch are easily cut with a mower, but some difficulty may be experienced in cutting hairy vetch. This can be partly overcome by having a man follow the mower with a fork to keep the vetch from clogging on the cutter bar or by throwing the swath out of the way as soon as it is cut.

The problem of curing and handling vetch hay is much the same as with cowpeas. In favorable weather vetch may be cured in the swath and windrow, but ordinarily it should be raked and shocked when partly cured. After the hay is raked into windrows, it may be bunched with an ordinary dump rake or sweep rake, thereby decreasing the labor in shocking. Shocks should be tall and narrow to prevent heating in the middle. They are sometimes built on racks that keep the inside hollow and allow the hay to cure more rapidly.

MIXTURES FOR HAY.

For maximum yield and ease in handling the hay some other crop should be planted with vetch. Oats, rye, wheat, or barley may be used for this purpose. As a small-grain crop makes the best hay when cut in the dough stage, the variety of grain planted should be governed to a certain extent by the time it is desired to cut the vetch. Burt oats will be found satisfactory for early harvesting, and the Appler variety is suitable for later cuttings. When planted for pasture, vetch does well with any small grain. When planted for hay, hairy vetch especially needs a grain crop to hold it off the ground, as it then makes a better yield. On suitable lands, from 2 to 4 quarts of crimson clover seed to the acre may be planted with vetch and the native grasses, such as Johnson grass and Bermuda grass, for hay or pasture.

PRODUCTION OF VETCH SILAGE.

Vetch makes good silage and is ready at a time of year when the corn silage is likely to be exhausted. Hay and silage making may be worked together. When the weather is favorable, the vetch may be cured for hay, and in rainy weather it may be cut for silage, so that but little time need be lost in harvesting. A large dairy farm near Columbia, S. C., uses vetch in this way, feeding the silage to dairy cattle with good results.

PALATABILITY OF VETCH FORAGE.

Reports from farmers differ as to the palatability of vetch. Some say that stock will not eat it, others report that they gradually become accustomed to it, and still others that all kinds of animals eat it readily. A number of farmers use it extensively for swine pasturage. The green forage of the native vetch and of common vetch is more readily eaten than that of hairy vetch, but when cut for hay there is no apparent difference. It is the common opinion among farmers that vetch hay ranks higher in palatability as compared with other crop than does the green forage. No difficulty seems to be experienced in getting young stock to eat vetch.

PRODUCTION OF VETCH SEED.

The source of seed has an important bearing on vetch growing in the South Atlantic States. The seed of " native " or narrow-leaved vetch can rarely be purchased in the market. Since the pods burst open when ripe, it is almost impossible to gather any quantity of the seed. Where oats are sown on land on which narrow-leaved vetch is growing, the oats and vetch may be cut together, and by binding into bundles the vetch seed is saved though the pods burst open. When thrashed, the oats and vetch will be mixed together. When narrow-leaved vetch is mixed with Johnson and Bermuda grasses some seed can be saved by placing a blanket under the baler when the hay is baled. Anyone desiring to grow narrow-leaved vetch, however, must depend mainly on its reseeding itself. This it does very well on meadows and in pastures where it is not grazed too close, as considerable seed becomes shattered by the time the native grasses are ready to cut for hay.

Thus far, practically the entire supply of seed of the common and hairy vetch has been obtained from European markets. Seed of common vetch may be purchased from growers in Oregon, but the western demand and high transcontinental freight rates make Oregon seed more expensive than that from France, Germany, and England. Hairy vetch seed is mostly imported from Russia and Germany, as there is no adequate supply in this country.

Vetch growers should consider the production of their own seed. No attempt has yet been made in the South Atlantic States to harvest common vetch for seed. It can be cut with a binder and thrashed with an ordinary thrasher like wheat and oats. In Oregon, fair yields are from 10 to 20 bushels per acre, ordinarily worth from $1.50 to $2.25 per bushel. Common vetch does not reseed itself well.

Hairy vetch can be made to reseed itself by cutting early, before the leaves and stems near the ground begin to die. It will then continue to grow and set sufficient seed to reseed the land by June 10. Or, if cut late, after the lower pods have matured, enough seed will shatter out in handling to reseed the land. In either of these cases the land should not be plowed too deep for the summer crops which follow, nor should these crops be cultivated too late, as the seed may be buried too deep to come up or too many plants be killed to leave a stand. If the land is not plowed at all or no summer crop is planted; the seed will germinate and come up in the fall, unless the grasses are too thick. When left to reseed itself on Bermuda or Johnson grass sod, hairy vetch will gradually disappear in the course of three or four years.

Hairy vetch can be thrashed for seed with the ordinary grain thrasher. For producing seed, vetch should be sown by itself, or with only a small quantity of oats or wheat, so as to make the percentage of vetch seed in the mixture as high as possible when thrashed. If there is too large a proportion of oats for a proper mixture, the oats can be removed by running through a fanning mill. Special machines to separate the grain from the seed are on the market.

Hairy vetch ripens its seed unevenly, so that the time of gathering should be whenever there is a good crop of seed ready to harvest. This is usually after the bottom pods have become dry and burst open. If hairy vetch is well matured, it can be harvested without cutting by raking it up into windrows with an ordinary hayrake. If the rake does not get it all the first time, the field should be gone over again in the opposite direction. This should be done when the vines are damp, to prevent the seed from shattering. If this method is not satisfactory, as is sometimes true on stiff land where the roots are held firmly in the ground or where some other crop is planted with the vetch, it will be necessary to use a mower. After the vetch is raked or cut it can be piled and left until hauled to the thrasher.

Hairy vetch usually yields about half as much seed per acre as common vetch when planted in the same region. On a farm near Newberry, S. C., a field of hairy vetch, estimated to make 1½ tons of hay per acre, yielded 3¾ bushels of seed to the acre. Hairy vetch seed varies in price from $4 to $9 per bushel of 60 pounds, so that under ordinary conditions seed production should be a profitable operation. This is especially apparent when it is noted that the thrashed straw makes a fair quality of hay, that enough seed has shattered out to reseed the field, and that nitrogen and humus have been added to the soil.

VETCH HONEY.

Vetch growers report that while the vetch is in bloom bees make two or three times as much honey as at any other time in the year. From 25 to 50 pounds of vetch honey per stand of bees is obtained during the season. Vetch honey is white and clear and of excellent quality.

ROTATIONS WITH VETCH.

Vetch, being a winter crop in the Southern States, is well adapted to use in rotations with ordinary crops, as it can be grown without seriously interfering with some of the summer crops. The following rotations are suggested for the various conditions.

ROTATIONS FOR BOTTOM LANDS.

Low lands subject to overflow should be devoted to pasture or hay growing. Cultivated crops, such as corn and cotton, are more easily damaged by high water in case of an overflow, and the loss is greater than with hay or pasture. Vetch can be used on such lands with the native grasses, oats, cowpeas, and Johnson grass in various rotations, three of which now practiced in the South Atlantic States are shown in Table I.

TABLE I.—*Three rotations showing how vetch is used with native grasses, oats, and Johnson grass for hay or pasture on overflow bottom lands.*

Rotation.	Winter.	Summer.
First	Vetch and native grasses	Johnson grass.
Second	Oats and vetch	Do.
Third:		
First year	do	Do.
Second year	do	Cowpeas.

In the first rotation narrow-leaved vetch should be used, as it is the only vetch that will reseed itself and hold its own with Johnson grass year after year. A large part of the seed is ripe and scattered by the time the first cutting is made and being hardy it gains a foothold and makes a stand the following year. A farmer near Chester, S. C., reports as follows: "In a creek bottom where three years ago there was little or no vetch in a native grass meadow the narrow-leaved vetch is gradually spreading over the field." This rotation is common in the Savannah and Congaree river bottoms. Vetch has a twofold purpose in this rotation: (1) Johnson grass is not ready to cut until late in the spring, so that, if vetch is not grown, weeds will grow on the land and one cutting of hay is lost; and (2) the vetch adds nitrogen to the soil, which causes a heavier growth of the Johnson grass.

In the second and third rotations it is necessary to plow the land in order to sow the oats and vetch. Either common or hairy vetch may be used, depending on the character of the soil. On loamy, moist soils some vetch growers plant three-fourths common and one-fourth hairy vetch, thereby extending the haying period. Any of these rotations are also suitable for uplands.

The western corn rootworm appears to be gradually working its way southward where corn is grown continuously on bottom lands. A rotation of crops is an effectual preventive and it would seem that vetch might be here profitably employed as an alternating crop.

ROTATIONS FOR MIXED FARMING ON UPLANDS.

Where it is desirable to make a specialty of hay on a mixed farm on uplands, the following rotation, shown in Table II, of vetch with corn, cotton, oats, and cowpeas may be used.

TABLE II.—*Rotations of vetch with corn, cotton, oats, and cowpeas for mixed farming on uplands.*

Year.	First field.	Second field.	Third field.
First	Cotton; vetch for winter cover crop.	Corn with cowpeas between rows.	Oats and vetch; cowpeas.
Second	Corn with cowpeas between rows.	Oats and vetch; cowpeas.	Cotton; vetch for winter cover crop.
Third	Oats and vetch (winter); cowpeas (summer).	Cotton; vetch for winter cover crop.	Corn with cowpeas between rows.

This rotation is especially recommended for the Piedmont section where the land is likely to wash and cultivation is difficult. On clay lands that become hard in dry weather or can not be plowed after a rain, oats and vetch handled carefully do well. Hairy vetch properly inoculated and planted has made good growths even on bald clay spots. Sorghum is frequently used in place of the cowpeas in this rotation.

ROTATIONS FOR DAIRY FARMS.

In dairy farming, where plenty of forage is needed, vetch can be used for silage, hay, or pasture in a 3-year rotation with oats, corn, and cowpeas, as shown in Table III.

TABLE III.—*Vetch in 3-year rotations with oats, corn, and cowpeas on a dairy farm.*

Year.	First field.	Second field.	Third field.
First	Early corn with cowpeas between rows.	Oats and vetch; cowpeas.	Oats and vetch; silage corn.
Second	Oats and vetch (winter); cowpeas (summer).	Oats and vetch; silage corn.	Early corn with cowpeas between rows.
Third	Oats and vetch (winter); silage corn (summer).	Early corn with cowpeas between rows.	Oats and vetch; cowpeas.

In this rotation, the oats and vetch may be used for making silage or pasture. With the barnyard manure returned to the soil there will ultimately be an excess of nitrogen. This can be reduced by planting silage corn or sorghum instead of cowpeas after the oats and vetch.

ROTATIONS FOR COTTON FARMS.

Table IV shows how vetch can be used in a system of cotton farming with cotton, corn, oats, and cowpeas.

TABLE IV.—*Vetch in rotations with cotton, corn, oats, and cowpeas on a cotton farm.*

Year.	First field.	Second field.	Third field.	Fourth field.
First	Cotton	Oats and vetch; cowpeas.	Cotton; vetch for winter cover crop.	Corn, with cowpeas between rows.
Second	Oats and vetch; cowpeas.	Cotton; vetch for winter cover crop.	Corn, with cowpeas between rows.	Cotton.
Third	Cotton; vetch for winter cover crop.	Corn, with cowpeas between rows.	Cotton	Oats and vetch; cowpeas.
Fourth	Corn, with cowpeas between rows.	Cotton	Oats and vetch; cowpeas.	Cotton; vetch for winter cover crop.

The vetch preceding the cowpeas in this rotation should be handled so that it may reseed itself for a winter cover crop. The land should be plowed shallow or disked for cowpeas to avoid covering the vetch seed too deep. It will be necessary to go over heavy growths of vetch with a disk harrow or stalk cutter before they can be turned under.

EXPERIENCES OF FARMERS WITH VETCH.

South Carolina is growing more vetch than any other of the Southern States. The experiences of some of these farmers are shown in the following characteristic reports, some of which were secured through the cooperation of the Farmers' Cooperative Demonstration Work:

E. A. Brown, Kershaw County.—Planted hairy vetch on sandy loam soil without inoculation. The vetch was a failure. Inoculated the second year and made a success.

M. W. Doty, Fairfield County.—Planted hairy vetch on light, sandy land and inoculated the seed with vetch culture from the United States Department of Agriculture. A good stand was secured, but only a few spots became inoculated; the remainder died. The vetch was plowed under, barnyard manure was applied, and the land sowed in cowpeas. Vetch was planted again the next fall and a heavy growth was made. Cotton following the vetch made a heavier yield than where no vetch was planted.

A. D. Hudson, Newberry County.—Planted hairy vetch on poor clay land in September. The first year no inoculation was used, and vetch was practically a failure. Inoculated soil the next year, sowed in September, and obtained 1½ tons of hay per acre. Hairy vetch planted in cotton where soil was inoculated did well. Common vetch did not yield as well as hairy vetch. Now plant nearly one-third of the farm in vetch every year.

R. A. Hudson, Fairfield County.—Planted hairy vetch on a clay soil; used no fertilizer and inoculated with soil; made 2,400 pounds of hay per acre.

R. O. Janson, Horry County.—Planted hairy vetch on sandy land with clay subsoil. Some barnyard manure and fertilizers were applied and a fair stand was secured. No inoculation was used, and the vetch was a complete failure.

T. C. Johnson, Florence County.—Planted hairy vetch on sandy loam soil after inoculating with soil from an old field. The inoculation the first year was not complete and only a partial success was made. The vetch was left to reseed itself, and a good stand, perfectly inoculated, came up in the fall. This made a heavy growth and was pastured with calves and colts with good results.

C. W. Josey, Lee County.—Planted hairy vetch on sandy loam soil following corn and peas; used soil for inoculation; made 2 tons of hay per acre.

George E. Showman, Orangeburg County.—Planted hairy vetch on light, sandy soil. Inoculated with soil. The vetch yielded 2,500 pounds of hay per acre. Some common vetch sowed in comparison with the hairy vetch made a complete failure.

Milton L. Sifly, Orangeburg County.—Secured inoculation by planting vetch year after year. Hairy vetch, oats, rye, and barley were sown in early September. It was grazed by cows and hogs in the spring and considered a success.

E. V. Turner, Fairfield County.—Planted hairy vetch on clay land in cotton after the second picking. Inoculation was obtained from wild vetch growing in the neighborhood. The fall was very dry, but a good stand was secured and a yield of from 1 to 1½ tons of hay per acre was made.

Jacob S. Wheeler, Newberry County.—Planted hairy vetch on sandy land that had become inoculated by a previous crop. The yield was 2½ tons per acre. The vetch was fed to milch cows with good results.

Welch Wilbur, Newberry County.—Inoculated land and planted 100 acres of vetch in cotton in September. Hairy vetch did better than common vetch. Hairy vetch yielded from 1 to 2 tons per acre. Some stands of bees gathered an average of 50 pounds of honey per stand from vetch.

U. Alvin Vincent, Florence County.—Planted hairy vetch on sandy land so poor that it could hardly grow cowpeas. The soil was inoculated with soil from another field. One ton of hay per acre was obtained and fed to horses.

SUMMARY.

Vetch is grown on practically all types of soil in the South Atlantic States.

Vetch can be used for hay, pasture, soiling, silage, honey production, and soil improvement.

Three varieties of vetch are now grown in these States, viz, "native" or narrow-leaved vetch; common, Oregon, or English vetch; and hairy or sand vetch.

In the latitude of South Carolina "native" or narrow-leaved vetch usually matures from April 15 to May 15, common vetch from May 10 to May 25, and hairy vetch from May 20 to June 10.

The narrow-leaved vetch grows wild, is hardy, will reseed itself, and will hold its own against native grasses. The common vetch is more easily handled and the seed is cheaper than that of other varieties, but it is not so hardy. Hairy vetch is hardy and for all conditions is the best variety for these States.

Vetch adds nitrogen and organic matter to the soil and is superior to cowpeas for increasing the productivity of land. It does for the soil in the winter what the cowpea does for it in the summer.

Vetch has a long planting period, but best results are obtained by planting from August 15 to October 15.

Vetch can be planted in cotton at the last working, or after the first or second picking. It can be planted after corn or cowpeas.

Forty-five pounds of common vetch or thirty pounds of hairy vetch seed per acre are sufficient for ordinary purposes.

The necessity for inoculation can not be too strongly emphasized; more failures have been made with vetch from lack of inoculation than from any other cause. The seed should be inoculated with artificial vetch cultures or the land should be treated by transferring soil from an old field to the new one. Other methods sometimes employed are to plant a small amount of seed on the land until inoculation is secured or to apply barnyard manure made from vetch. A field that has once grown vetch successfully will not require inoculation again unless it is not planted in vetch for several years.

Small grains should be sown with vetch to hold it up and to allow the hay to be more easily cured. This is more necessary with the hairy vetch than with the other varieties.

Most of the hairy vetch seed now used is imported from Europe, but it can be and should be produced in the South Atlantic States.

Vetch hay is cured similarly to cowpea hay.

Vetch can be used in rotations for hay, dairy, cotton, and general farming.

The experiences of farmers show that all kinds of stock will eat vetch and that by proper inoculation and seeding it can be grown successfully on all ordinary soils in the South Atlantic States.

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FARMERS' BULLETIN 530.

IMPORTANT POULTRY DISEASES.

BY

D. E. SALMON, D. V. M.

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1913.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., March 6, 1913.

Sir: I have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, a treatise by Dr. D. E. Salmon on "Important Poultry Diseases."

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. D. F. Houston,
Secretary of Agriculture.

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IMPORTANT POULTRY DISEASES.

INTRODUCTION.

Fowls are liable to be affected by a considerable number of diseases, some of which spread rapidly through the flock and kill a large part of the birds. They may also be infested by various kinds of parasites, some of which live on the surface of the body and others in the crop, stomach, or intestines. These parasites are injurious because they take a part of the nourishment which should be used by the bird to put on flesh or to produce eggs, and also because by their movements and their biting they cause irritation and inflammation of the parts which they attack.

The contagious diseases, which are caused by animal and vegetable germs, and the weakness and loss of flesh caused by the larger parasites to which reference has just been made, are the most important conditions which the poultryman has to consider in the endeavor to keep his birds in a healthy condition. These germs and parasites should be kept out of the flock by suitable preventive measures, because disease may be avoided in this way much more easily and cheaply than it can be cured. The aim in studying the diseases of birds is, therefore, to learn how to prevent such diseases rather than how to cure them.

There are some cases in which medicines may be advantageously given or applied to fowls, but as a rule when a bird becomes sick it is better to kill it, because the cost of the medicine and the value of the time required to carry out the treatment are greater than the value of the birds which are cured. Another reason for killing sick birds is that they may be affected by a contagious disease which before it is recognized may spread to many other birds in the flock. A third reason for killing is the fact that a bird being sick indicates that it is more susceptible to disease than the other birds of the flock, and in order to establish a flock which is able to resist disease such susceptible birds must be weeded out.

The greater the number of birds which are kept upon any farm or plot of ground, and the more they are crowded together, the greater is the danger from contagion and parasites, and the more important are the measures for excluding, eradicating, and preventing the development of these causes of disease.

HOW TO PREVENT DISEASE.

It is very important to start right and begin the flock with birds which are free from contagion and parasites, and to put such birds upon ground which is likewise free from these causes of disease.

The best way to accomplish this is to get eggs from a flock which has shown no indications of contagious disease for at least a year; avoid putting these eggs in any packing such as chaff, oats, or cut straw which may be musty or moldy; wipe the eggs with a cloth wet in 70 to 80 per cent alcohol, and hatch them in a new or thoroughly cleaned incubator. The young chicks should be free from parasites and injurious germs of all kinds, and, to keep them in this condition, they should be put in new or clean brooders and permitted to run only upon ground where poultry has not previously been kept or which has not been used for poultry for several years.

Sometimes these directions can not be followed in all respects. If all the available ground has been recently used for poultry, the fowls should be removed from that part which is to be used for the new flock, a good coating of freshly slaked lime should be applied to the entire surface of the ground, and a few days later it should be plowed. It may now be cultivated three or four times with intervals of a week and finally sowed with oats, rye, or other grain. In a few months the greater part of the germs will be destroyed, but it is best to leave the ground unoccupied by fowls until a winter has passed, as the freezing and thawing of fall and spring is more effective than either continued cold or warm weather.

If the eggs must be hatched under hens instead of in the incubator, the problem of starting a clean flock is much more difficult. Hens are liable to harbor parasitic worms in their intestines and to scatter the eggs of these worms with their manure wherever they go. They generally have lice and mites hidden in their feathers, which pass to the young chicks immediately after the latter are hatched; and they may be the carriers of disease germs even when they appear perfectly healthy. For these reasons the hens which are used for hatching should be selected from a flock that is known to have been free from other diseases than those caused by accidents for at least a year, and the individual birds of which are lively, vigorous, free from lice and mites, and producing a large number of eggs.

The hens selected for hatching should be well dusted with a good lice powder before they are given a setting of eggs; their nests should be perfectly clean and should be made with fresh, soft hay or straw; and there should be a box of road dust, or sifted hard-coal ashes or similar substance, under cover, where they can dust themselves whenever they come from the nest. When the young chicks are taken from the nest they should be carefully examined for lice. These parasites usually accumulate under the throat and upon the top and back of the head. If any are found, rub a little sweet oil, pure lard, or vaseline with the finger over the parts where the lice are. This kills the lice by obstructing their breathing pores and does not harm the chicks.

By beginning in this manner, a flock may be obtained which is practically free from disease germs and parasites, but in order to keep it in this condition the premises must be frequently cleaned and occasionally disinfected. There are a number of reasons for this. First, there are certain germs generally present in the intestines of healthy fowls and that are scattered with the manure, which when they are permitted to accumulate and become very numerous may cause outbreaks of disease; secondly, the germs of contagious diseases may be brought to the poultry yard by pigeons or other birds which fly from one poultry yard to another, or by mice or rats; thirdly, it is seldom that grounds are obtained for the poultry yard which are entirely free from infection with the eggs of parasitic worms and the spores of disease-producing microbes. To keep these germs and parasites from developing and increasing their numbers to a dangerous extent, the houses should be kept clean, the drinking fountains and feed troughs should be washed every day or two with boiling water or other disinfectant, and, if any lice or mites are found on the birds or in their houses, the roosts and adjoining parts of the walls should be painted with a mixture of kerosene, 1 quart, and crude carbolic acid or crude cresol, 1 teacupful (1 gill). Or the house may be whitewashed with freshly slaked lime or sprayed with kerosene emulsion. The fowls should be dusted every three or four days with lice powder until these parasites entirely disappear, which should be within two weeks, if these measures are properly applied.

LICE POWDERS AND THEIR APPLICATION.

Very good lice powder may be made at little cost by mixing fine road dust, 2 quarts, and tobacco dust, 1 pint. In place of road dust, anthracite coal ashes well sifted may be used, and Persian insect powder or flowers of sulphur may be substituted for the tobacco dust. The important point is that all the ingredients should be in the form of a very fine dust.

A powder much recommended is made by mixing 3 parts gasoline and 1 part crude carbolic acid (90 to 95 per cent pure) and adding to this mixture slowly, while stirring, enough plaster of paris to take up all the moisture. It takes about 4 quarts of plaster of paris to 1 quart of the liquid. When enough plaster is added the mixture should form a dry, brownish powder. Those who make this powder should remember that gasoline is very inflammable and may cause an explosion if there is any fire near; also that crude carbolic acid of this strength may burn the hands, face, or eyes if it comes in contact with them.

Lice powders are best applied by putting them into a tin can having a perforated top like a pepper box, but with larger holes. A newspaper is spread on the floor to catch the surplus powder, the fowl is held by the legs, head downward, so that the feathers will loosen up and fall away from the body, and then the powder is dusted thoroughly through the feathers, especially under the tail and wings and about the neck and head. By rubbing the feathers slightly with the hand the powder will penetrate and form a coating over the skin, which is destructive to both lice and mites.

It is possible and practicable to keep a flock of poultry absolutely free from lice and mites, and this should be the aim of everyone who is endeavoring to establish a successful poultry industry.

DISINFECTANTS AND THEIR APPLICATION.

Good disinfectants destroy the germs of contagious diseases, the external parasites such as lice and mites, and the embryos of the intestinal worms. They should be thoroughly applied to the interior of the houses, worked into all the cracks and crevices, spread over the ceiling and the floor, the roosts, dropping boards, and nest boxes. At the same time, the feeding and drinking troughs should be disinfected by pouring boiling water into them and afterwards drying them in the sun. The disinfectants are most easily applied to the walls and ceilings with a spray pump or brush. As it is difficult to keep them from coming into contact with the face and hands, the more harmless of these mixtures should generally be used. Ordinarily limewash made from freshly slaked lime is excellent and its properties are well known to all. In the case of an actual outbreak of virulent disease, it is well to add to the limewash 6 ounces of crude carbolic acid to each gallon, to increase its activity as a disinfectant.

The kerosene emulsion which is frequently used to destroy lice and mites may readily be converted into a disinfectant. To make the emulsion shave ½ pound of hard laundry soap into ½ gallon of soft water and boil the mixture until all of the soap is dissolved, then remove it to a safe distance from the fire and stir into it, at once, while still hot, 2 gallons of kerosene oil. This makes a thick, creamy emulsion, or stock mixture. When it is to be used for killing lice in the houses 1 part of this emulsion is mixed with 10 parts of water. When it is to be used as a disinfectant add 1 quart of emulsion to 10 quarts of water and stir well; then add 1 pint crude carbolic acid or crude cresol and again stir until all is well mixed.

One of the best disinfectants is the compound solution of cresol, which may be purchased ready for use. It contains 50 per cent of cresol, and 1 pint of it added to 10 quarts of water makes a solution of the proper strength to apply to the houses or to spray over the ground. A 5 per cent solution of carbolic acid (1 pint carbolic acid to 10 quarts of water) is about equally efficacious. The choice between the two is a matter of convenience.

CHOLERA AND CHOLERA-LIKE DISEASES.

There are several diseases which have been investigated and described as different because the bacteria which cause them differ in some of their characteristics. The symptoms and the changes which are seen after death are so nearly identical that it is only by studying the bacteria that any one of these diseases can be distinguished from the others. The treatment applicable to one is equally applicable to the others. For the practical purpose of combating them in the poultry yard we may therefore group these diseases together.

Causation.—There are certain germs (bacteria) which are nearly always found in the intestines of healthy fowls which have more or less power to produce disease, but which the sound, healthy fowl is able to resist under favorable conditions. If these germs are inoculated into canary birds, they produce a fatal disease, because the canary does not have the power to resist them. If inoculated from one canary to another three or four times, these germs have their disease-producing powers so increased that they are able to kill adult fowls. When the resisting powers of fowls are diminished by exposure to cold, hunger, thirst, and exhaustion, as occurs during long shipments by rail, these germs may also cause disease in the fowls. In some countries the sickness which develops from these conditions is called " the transportation disease."

It sometimes happens that this disease develops in poultry yards which are not kept clean, possibly because of the large numbers of these germs which are taken into the bodies of the birds, but probably because they have acquired greater disease-producing powers from growing in warm manure. When they begin growing in the tissues of fowls they soon increase their virulence, and the disease which they cause may rapidly spread from fowl to fowl until the greater part of the birds are dead.

The typical germ of fowl cholera has adapted itself more completely than have these common germs to the conditions of life within the fowl's body, so that it is strictly parasitic, and is only obtained from fowls which are affected or have been affected with the disease. That is, birds only contract true fowl cholera by exposure to contagion that originates in other birds that have or have had the disease.

The cholera-like diseases may, therefore, either develop in the poultry yard from insanitary conditions, or they may be introduced by contagion carried by new birds which are added to the flock, by birds which have been to exhibitions, by wild birds which fly from one poultry yard to another, or by various animals, such as dogs, cats, rats, etc. Birds which recover from the disease may sometimes carry the germs and disseminate the contagion for six months or a year after they are apparently well.

Symptoms.—The first symptom is a yellowish coloration of that part of the excrement which is secreted by the kidneys and which in health is nearly or perfectly white. Soon there is diarrhea, the droppings consisting of the whitish or yellowish secretions of the kidneys mixed with considerable thin mucus and a small quantity of intestinal contents which may have a yellowish, brownish, or greenish color. There is considerable fever, and soon after the bird is attacked it loses its lively appearance, separates itself from the flock, and appears dull, dejected, and sleepy. It no longer searches for food, but sits with the head drawn down to the body or turned backward and resting in the feathers about the wing. The plumage soon loses its brilliance, the wings droop, the appetite is diminished, and the thirst increased; the comb and wattles may be a dark bluish red from engorgement with poorly oxygenated blood, or they may be pale and bloodless on account of the congestion of the internal organs, especially the liver.

The affected birds soon become very weak, drowsy, and often sleep so soundly during the last day or two of their lives that it is difficult to arouse them. If made to move, they stagger forward for a few steps only in an uncertain manner and with dragging wings. The crop is generally distended with food and apparently paralyzed, and the feathers about the vent are soiled and sometimes pasted together with excrement.

As death approaches, the weight and the strength of the bird rapidly diminish, it breathes with difficulty, sits with the beak open, and the breathing may be heard at some distance. Finally the weakness is such that the beak is rested on the ground, and a little later the bird falls over on one side, makes a few convulsive movements, and dies.

In the very acute cases no symptoms are seen; the birds may be found dead under the roosts, or they may fall at the feed trough and die in a few minutes.

The cholera-like diseases often occur in a chronic form, which may follow an acute attack of the disease or may be chronic from the first. This form is characterized by a continually increasing weakness, loss of weight, bloodlessness, and, finally, an exhaustive diarrhea. Sometimes one or more joints of the wings or feet swell, the birds become very lame, and later the swellings break and discharge a creamy or cheesy mass which contains large numbers of the germs.

These diseases may destroy the greater part of a flock in a week and then disappear, or they may linger for months, only occasionally killing a bird. The time between exposure to the contagion and the appearance of symptoms is from 2 to 5 days, and the duration of the disease is from 24 hours to 10 days.

The most characteristic changes seen after death are red spots on the surface of the heart, which gives it the appearance of having been sprinkled with blood, congestion and enlargement of the liver, and swelling of the spleen.

Treatment.—The best method of treatment is to kill the sick fowls in such a way as not to spread the infection with their blood, burn or deeply bury their bodies, separate the remaining birds into small lots of 3 to 5 each, so that when a bird is attacked there will not be more than this number exposed to it; then watch each lot so as to remove any sick bird as soon as symptoms appear. Disinfectants should be used in the houses and yards where the disease first appeared, and also in the small pens in which the separated birds are kept.

If it is deemed advisable to treat the sick birds, they may be given 2 to 4 teaspoonfuls of a one-half per cent carbolic solution twice a day. This is generally made by adding 1 part of the 5 per cent solution to 9 parts of water. They should also be given buttermilk to drink.

Generally the best results are obtained by killing the sick birds and separating the well ones into small pens and giving to each one 2 doses of the carbolic acid solution daily for three or four days. The houses and yards should be thoroughly cleaned and disinfected before the fowls are returned to them, and should be kept very clean for some weeks afterwards to guard against a recurrence of the disease.

ROUP OR CONTAGIOUS CATARRH.

The disease called " roup " by poultrymen is a contagious catarrh, closely resembling the more malignant forms of influenza in the larger animals and in man. It attacks principally the membranes lining the eye, the sacs below the eye (infra-orbital sinuses), the nostrils, the larynx, and the trachea. It is attended with high fever and is very contagious.

Causation.—Roup appears to be a strictly contagious disease; that is, one which arises only, so far as known, by contagion from other diseased birds. The nature of the microbe which constitutes the virus is not known. The contagion is generally brought into the poultry yard by infected birds. Sometimes these are birds which are purchased from other flocks in which the disease exists; sometimes they are birds of the home flock which have been to exhibitions and there exposed to sick fowls; and sometimes they are wild birds or pigeons which fly from one poultry yard to another.

The saliva and the discharge which escapes from the nostrils carry the contagion, and soon contaminate the drinking water and feeding troughs so that all the fowls are infected. Even the flocks in adjoining yards are infected by the particles of mucus projected into the air when sneezing, or by the contagion carried on the feet of persons, animals, or small birds that pass from one yard to another.

Delicate birds are inclined to severe attacks and to recover slowly, and often a chronic condition persists for a long time. Birds so affected may carry and spread the contagion for a year or more and become the cause of new outbreaks of the disease.

Symptoms.—The symptoms first seen are very similar to those of an ordinary cold, but there is more fever, dullness, and prostration. The discharge from the nasal opening is at first thin and watery, but in two or three days becomes thick and obstructs the breathing. The inflammation, which begins in the nasal passages, soon extends to the eyes and to the spaces which exist immediately below the eyeballs (infra-orbital spaces). The eyelids are swollen, held closed much of the time, and may be glued together by the accumulated secretion. The birds sneeze and shake their heads in their efforts to free the air passages from the thick mucus. The appetite is diminished and the birds sit with their heads drawn in, wings drooping, and having a general appearance of depression and illness.

When the inflammation reaches the spaces or sacs beneath the eyes, it causes the formation of a secretion very similar to that of the nose, and as this becomes thick it collects, distends the walls of these spaces, and produces a warm and painful swelling, which is seen just below the eyes and may reach the size of a hickory nut. This swelling presses with much force on the eyeball, which is displaced and more or less deformed; and in extreme cases even the bones of the head may give way before it.

The closure of the eyes prevents the badly affected birds from finding food; the accumulation of mucus in the nostrils completely obstructs these passages, so that the beak must be kept open in order to breathe; the obstruction of the windpipe and the smaller air tubes causes loud breathing sounds and difficult respiration.

In the severe and advanced cases the birds sit in a somnolent or semiconscious condition, unable to see or to eat; their strength is rapidly exhausted, and many of them die within a week or ten days. A part of the affected individuals recover, but others continue weak and have a chronic form of the disease for months, during which time they continue to disseminate the contagion.

This disease is distinguished from diphtheria by the absence of the thick, tough, and very adherent newly formed membranes (false membranes) in the nostrils, mouth, and throat which are characteristic of the latter. There may sometimes be a deposit of yellowish material on the walls of the mouth and throat, but it is easily broken up and removed.

Treatment.—The medical treatment of this disease may be very successful if properly applied. The sick birds should be removed from the flock and put in a warm, dry, and well-ventilated room which is free from drafts of air. The affected mucous membranes should then be treated by applying antiseptic and healing mixtures. The best method is to use a good spraying apparatus; but, lacking this, a small syringe, an oil can, or even a medicine dropper can be made to answer the purpose.

It has been recommended that the bird's head be plunged into a basin or bowl of the mixture and held there a few seconds, but not long enough to cause suffocation.

The remedies most suitable for such treatment are: Boric acid, 1 ounce; water, 1 quart. Or, permanganate of potash, 1 dram; water, 1 quart. Or, boric acid, 1¼ ounces; borate of soda, ½ ounce; water, 1 quart. Or, peroxid of hydrogen, 1 ounce; water, 3 ounces.

Where the inflammation has progressed to the eye, excellent results have followed the use of argyrol. One or two drops of a 15 per cent solution is introduced between the eyelids twice daily for a period of several days.

Before applying these remedies it is well to wash the eyes and mouth with warm water containing 1 teaspoonful of common salt to a quart, using a pledget of absorbent cotton and rubbing gently, while at the same time pressing and massaging about the nostrils and under the eyes to loosen the accumulated secretion. If there is much swelling under the eyes, it must be carefully opened with a sharp, clean knife, all the secretion removed, and the cavity washed with one of the above-mentioned solutions. A pledget of cotton moistened with the solution may be left in the opening for an hour or two, or it may be dusted with iodoform powder. When the swelling under the eye is not very large or hard, it may often be reduced by massaging it in such a manner as to press the contents toward the nostril. After treating the birds in this manner the head should be well anointed with pure vaseline or with camphorated vaseline.

The treatment of sick birds requires much time and patience, and there is always the risk that they may carry the contagion for several months after they are apparently well. Prevention is therefore much more profitable. To accomplish this, measures should be continually enforced which will exclude contagion of all kinds. New birds and those which have been to exhibitions should be isolated and kept under observation for two weeks before they are put with the flock, and all animals and wild birds excluded, so far as possible. The houses should be kept clean and dry and occasionally disinfected. If the disease appears notwithstanding these precautions, isolate the affected fowls at once at a distance from the well ones, and apply disinfectants freely about the houses and runs. Also place sufficient permanganate of potash in all drinking water to give the latter a deep red color. If the disease proves of a severe type, it is often better to kill the entire flock, and after a thorough cleaning and disinfection of the premises to begin with new birds. This radical method avoids the retention of birds which may harbor the contagion and cause the development of subsequent outbreaks.

DIPHTHERIA.

Diphtheria is a disease having some of the symptoms of a cold, or of the contagious catarrh described above, but which differs from these and is especially characterized by the development of false membranes on the mucous surface of the nostrils, eyes, mouth, throat, and even of the smaller air tubes. The false membranes are new growths of a grayish or yellowish color, very tough, and very difficult to remove from the tissues beneath them.

Causation.—The diphtheria of fowls is caused by a filterable and invisible virus, and therefore is entirely distinct from the diphtheria of children, which is caused by a well-known bacillus. The disease is strictly contagious, and probably never develops as the result of exposure to cold and dampness, although these conditions favor its spread and tend to increase its malignancy. The contagion is generally introduced by newly purchased birds or by birds which have been to exhibitions and there exposed to sick fowls. Sometimes it is carried by pigeons and other small birds. Very often an outbreak is caused by contagion from an apparently well bird which had the disease and recovered months before.

The contagion is spread through the mucus which escapes from the nostrils, or that which is forced out in the acts of sneezing or coughing, in the saliva, the secretions of the eyes, and also the excrement. When the disease appears in a flock the floors of the houses, the drinking cups, and feeding troughs are at once infected by the diseased birds, and the well ones soon contract the disease from the contaminated water and food. It is consequently but a few days before a large part of the flock shows symptoms, though some are much more severely affected than others.

Symptoms.—Diphtheria begins as a local irritation or inflammation at some point on the internal surface of the mouth, throat, nostril, or eyes. At this time the general health is not yet affected, and there is nothing but the diphtheritic deposit to indicate that the bird has been attacked. This deposit is at first thin, yellowish or whitish in color, and gradually becomes thicker, firmer, and more adherent, so that considerable force is required to remove it. The mucous membrane beneath the deposit is found, when the latter is removed, to be inflamed, ulcerated, and bleeding, but it is soon covered by a new deposit. This deposit is called a false membrane, and when it is situated where the air passes over it in breathing it dries, becomes uneven and fissured, and its color changes to a dark brown.

With pigeons the deposit is more friable and easily removed, and the mucous membrane beneath it is reddened but not ulcerated.

While the false membranes over the parts first affected are becoming thicker, the inflammation extends to the adjoining surfaces, and new diphtheritic centers develop, uniting with each other until the cheeks, the tongue, the palate, the throat, and the inside of the nostrils are covered. Very often the inflammation extends from the nostrils to the eyes and the sacs beneath the eyes, and sometimes it penetrates the air tubes to the lungs or the gullet to the crop.

This extension of the disease leads to the appearance of other symptoms. The inflammation in the nostrils causes sneezing and the escape of a thin, watery secretion from the nasal openings; the thick false membranes fill up the nasal passages and the throat and obstruct the breathing; a thick, viscid secretion collects on the eyelids and glues them together; the sacs under the eyes fill up, and swellings are caused which disfigure the head; the poison which is produced by the growth of the microbe beneath the false membranes is absorbed and affects the nervous system, causing dullness, depression, and sleepiness. The affected bird stands with the neck extended and the beak open to facilitate the entrance of air into the lungs, and from the corners of the mouth there hang strings of thick, tenacious, grayish mucus. At this time, which may be three to five days from the appearance of the first symptoms, the condition is very serious. Swallowing is difficult or impossible; the breathing is so obstructed that hardly sufficient air can be inhaled to support life; the head is swollen; the eyes are nearly or entirely closed; the feathers of the head, neck, and breast are foul with the decomposing secretions from the nostrils and mouth; there is considerable fever; an exhausting diarrhea sets in; there is rapid loss of weight; the comb and wattles become pale and cold; the temperature of the body finally sinks below the normal; and death soon follows.

When false membranes form in the gullet, crop, and intestines, there is a rapid aggravation of the symptoms, an intense diarrhea, and the escape of blood with the droppings. This type of the disease is more frequent with water fowl than other birds. Some fowls in a flock are resistant, and after a few days of illness make a rapid recovery. Others remain dull, weak, and thin in flesh, and may have more or less catarrh and difficulty of breathing for a long time.

The period between exposure to the contagion and the appearance of the first symptoms varies from 3 to 15 days; the duration of the disease varies from 2 to 3 days to as many weeks in the acute cases, while the chronic form may continue for several months. The average death rate is from 50 to 60 per cent of the flock.

Treatment.—The treatment of fowls affected with diphtheria requires much time and patience, and as a rule does not pay. It is better to kill those affected, bury or burn their carcasses, disinfect the poultry houses, and in that way eradicate the contagion as soon as possible, even if the whole flock must be sacrificed.

If it is decided to treat the sick birds, they should be removed from the flock and put in a comfortable, well-ventilated room which may be easily disinfected. Make a solution by dissolving 2 drams of common salt in a quart of warm water, and with a soft brush or a pledget of absorbent cotton dipped in this solution gently brush or rub the false membranes until they are disintegrated and loosened from the underlying tissues. Sometimes it is necessary to scrape them off with a spoon or knife, but it must be done carefully so that bleeding will not be caused or the sensitive tissues injured. After the false membrane has been removed, moisten a pledget of absorbent cotton in a 2 per cent solution of lysol or carbolic acid and apply it for a minute or two to the diseased surface. A solution which gives good results is made by dissolving 35 grains of chlorate of potash and 2 grains of salicylic acid in 1 ounce of water and adding 1 ounce of glycerin. This may be applied to the diphtheritic spots three or four times a day with a pledget of absorbent cotton.

Another solution which is often recommended is made by dissolving 16 grains of permanganate of potash in half a pint of water. A very good and also a harmless solution consists of 1½ ounces of boric acid and 1 ounce of powdered borax (biborate of soda) dissolved in 1 quart of water and applied warm. The two last-mentioned solutions may be used to wash the eyes or may be injected into the nostrils. Argyrol may also be used as recommended in contagious catarrh.

If large swellings appear beneath the eyes, they should be opened with a clean, sharp knife, the contents of the cavity removed, and the space frequently washed with the boric-acid-borax solution mentioned above.

Many persons think that the treatment is not complete without fumigation. To accomplish this vaporize tar water or oil of turpentine in the room by dropping it slowly on a hot brick or stone after the doors and windows have been tightly closed. If the operator remains in the room with the fowls, he can easily determine when as much of the remedy has been vaporized as can safely be used and should stop at that point. The tar water is prepared by stirring two tablespoonfuls of wood tar in a quart of warm water and letting the mixture stand for a few hours.

The cages and the room in which the sick birds are kept should be disinfected daily with a 5 per cent solution of cresol or carbolic acid.

BIRD POX (CHICKEN POX).

Bird pox is a condition characterized by an eruption of nodules varying from the size of a millet seed to that of a pea, which occurs on the comb, wattles, ear lobes, and less frequently on the skin of other parts of the body. It is more frequent and more malignant in warm than in cold climates, but occurs in most parts of the world. Recent investigations make it probable that it is caused by a filterable virus which is identical with that of diphtheria. As the symptoms of the two conditions are generally quite distinct they are here described separately.

Causation.—Bird pox, so far as known, does not originate in any other way than by contagion. It seems to be produced by virus from fowls or pigeons affected with either the eruption of bird pox or the false membranes of diphtheria. Experiments have shown that both pox and diphtheria are easily inoculated from fowl to fowl and from pigeon to fowl, but the inoculation of pox from fowl to pigeon has proved very difficult and that of diphtheria impossible. The contagion is believed to exist in the blood as well as in the nodules which appear upon the skin.

The disease is generally introduced by new birds which are put into the flock or by exhibition birds which return infected. Probably it is often brought by pigeons, sparrows, and other birds which fly from one yard to another. The inoculation of the comb and wattles appears to occur by rubbing these parts with the infected feet or by being injured with the infected beaks of other birds.

The virus is quite resistant and requires thorough disinfection for its eradication.

Symptoms.—The eruption appears as round, oblong, or irregularly shaped nodules from the size of a pinhead to that of a pea or a hazelnut. They are seen especially about the beak and nostrils and on the comb, the eyelids, the wattles, and the ear lobes. In some individuals, and particularly in pigeons, the eruption is more generalized and is found on the skin of other parts of the body, as the neck, under the wings, on the rump, and about the cloaca. Here the nodules may become larger than on the head.

The nodules begin as small red or reddish-gray deposits with a shiny surface and gradually enlarge, while the color changes to a yellowish, brownish, or dark brown and the surface dries and becomes shriveled, uneven, and warty in appearance. Owing to the number of nodules and the extension of the inflammation, large patches of skin become thickened and covered with hard, dry crusts, closing the nasal openings or the eyelids and making it difficult even to open the beak.

In the milder cases the eruption is limited to the head, the nodules are distinct and small, and the general health of the affected bird does not suffer. The nodules soon dry, heal, and shrink; the crusts become loosened and fall off, and there is rapid recovery. In the more malignant cases the eruption is generalized over the surface of the body, the nodules are larger, and there is a diffuse inflammation and thickening of large areas of skin. If the crusts are rubbed or scratched off by the fowls, there occurs from the ulcerous surface a discharge at first watery, but later thick, yellowish, and viscid, which soils the feathers and, if abundant, gives off a disagreeable odor. This type of the disease is accompanied by fever, rapid loss of flesh, and prostration, and frequently causes the death of the victim. In the most malignant cases, especially with pigeons, the eruption extends to the mucous membranes of the eyes, nostrils, and mouth, causing a diphtheritic inflammation that is generally fatal.

Treatment.—The mild cases of this disease may be successfully treated by simple local applications. The crusts on the nodules are softened with carbolated ointment, glycerin, or oil, and after an hour or two removed by washing with warm water containing a little soap. The denuded tissue is then treated with a 2 per cent solution of creolin or lysol, or with a saturated solution of boric acid. Some prefer carbolated oil or carbolated ointment to watery solutions; others apply tincture of iodin. If there is much inflammation of the eyes, apply frequently with a medicine dropper or a pledget of absorbent cotton a solution made by dissolving 1½ ounces boric acid and 1 ounce biborate of soda in a quart of warm water. This solution may also be applied to the inflamed skin either before or after the crusts are removed.

As this disease is contagious, the houses, drinking vessels, and feed troughs should be kept disinfected during the outbreak and for some days after all the birds have apparently recovered.

BLACKHEAD (ENTERO-HEPATITIS).

This is a disease of the intestines and liver, which is most frequent with and most injurious to turkeys, but which also attacks common fowls. In the course of this disease the head often becomes dark colored or nearly black, and for that reason it is popularly known as "blackhead," although it is only the internal organs that are attacked by the parasitic microbe. The cause of the disease is a protozoal organism called *Amœba meleagridis*, the ameba of turkeys. The contagion is widely disseminated and in some localities has made the production of turkeys nearly impossible.

Causation.—The ameba leaves the bodies of the sick birds with the excrement and infects other birds by entering the digestive organs with the food and drink. It passes along the alimentary canal until it arrives at the two blind pouches or lateral extensions called the ceca, where it begins its growth and produces the first signs of disease. Here it penetrates the lining membrane, increases rapidly in numbers, and sets up an inflammatory process which leads to a great thickening of the intestinal wall and to the filling up and obstruction of the tube with an accumulation of yellowish white or grayish cheesy material that is deposited in concentric layers.

The changes which are almost constantly found in the liver are explained by assuming that the microbes are carried by the blood from the diseased ceca to the liver, and are there deposited at different points, where they multiply and spread in all directions. In this way are formed the numerous centers of disease which appear on the surface of the liver as yellowish spots, but which when cut across are seen to be irregularly spherical in shape. The ameba are liberated in large numbers both in the ceca and in the liver, are mixed with the intestinal contents, and are distributed with the droppings.

There is some difference of opinion as to whether the ameba is ever present within the egg of diseased turkeys, but the indications are that the infection is not carried in this way. It no doubt often exists on the outside of the shell, from contamination when the egg passes through the cloaca, and for this reason the eggs should be carefully cleaned before they are put under the sitting hen or into an incubator.

An important recent conclusion is that common fowls harbor this parasite, although they rarely suffer sufficiently from its attacks to show marked symptoms of disease. They scatter the contagion constantly, however, and young turkeys, being more susceptible, contract a fatal form of the disease and are nearly all destroyed by it. For this reason it is very difficult to raise turkeys on or near grounds where there are common fowls.

Symptoms.—The symptoms of blackhead are most frequently seen in young turkeys, commonly called " poults," which are from 2 weeks to 3 or 4 months old. When young poults are infected experimentally by feeding them diseased livers they usually die in about two or three weeks, but when infected naturally they generally take in a smaller quantity of contagion and live a longer time.

The affected birds at first appear less lively than usual, are not so active in searching for food, and when fed show a diminished appetite. Diarrhea is a nearly constant symptom, being due to the inflammation of the ceca. As the disease progresses there is more dullness and weakness, the wings and tail droop, and there is often the peculiar discoloration of the head which led to the disease being called "blackhead." There is increasing prostration and loss of weight; the affected birds, instead of following their companions, stand about in a listless manner, indisposed to move and paying little attention to what occurs about them.

The greater part of the affected poults die within three or four months after hatching; but with some the disease takes a more chronic form and does not cause death for a year or more. Nearly all die sooner or later from the effects of the disease, but in a small proportion of the cases there is healing and recovery.

The finding after death, in young turkeys, of the diseased and thickened ceca, plugged with cheesy contents, together with the yellowish or yellowish-green spots in the more or less enlarged liver are sufficient indications to warrant a diagnosis of blackhead.

Treatment.—The treatment of diseased birds has not given satisfactory results. The remedies most often used are sulphur 5 grains, sulphate of iron 1 grain; or benzonaphthol 1 grain, salicylate of bismuth 1 grain; or sulphate of iron 1 grain, salicylate of soda 1 grain. These remedies should be preceded and followed by a dose of Epsom salts (10 to 35 grains), or of castor oil (½ to 3 teaspoonfuls). Fifteen grains of catechu to the gallon of drinking water may also have a beneficial effect. It seems clear, however, that it does not pay to doctor the sick poults and that the only hope of success at present is in preventing their infection.

The measures of prevention which have been suggested are (1) obtaining eggs from birds believed to be healthy; (2) wiping the eggs with a cloth wet with alcohol (80 to 90 per cent) before they are placed in the incubator or under the hen for hatching, to remove any contagion that might be on the shell; (3) hatching in an incubator, or at least removing the eggs from under the hen a day or two before hatching would occur, wiping with alcohol, and finishing in an incubator, in order to avoid exposing the poults to the hen; (4) placing the young poults on ground at a distance from all other domesticated fowls and which has not recently been occupied by other fowls; (5) excluding so far as possible pigeons, other wild birds, and rats and mice from the houses and runs occupied by the turkeys; (6) the frequent disinfection of the houses, feed troughs, drinking fountains, etc.; (7) the immediate killing of diseased birds and the destruction of their bodies by fire.

These radical measures are necessary, and in sections of the country which are not too intensely infected they will make it possible to carry on the turkey industry successfully. However, it must be admitted that up to the present blackhead has proved to be the most difficult of all diseases to prevent or eradicate.

The destruction of the contagion, after it has been introduced into a poultry yard, has also been found difficult or impossible. Some have proposed to dig up and burn the surface soil to depth of several inches, which might be done with small yards but is impossible with large ones. In most cases the poultryman must be contented with the application of a layer of freshly burned lime that has been carefully slaked to a fine, dry powder. After a few weeks this ground should be plowed and another layer of lime applied. The manure which has accumulated should be burned or mixed with lime and plowed into the ground of some distant fields. The walls and floors of the buildings should be covered with a good limewash containing 6 ounces of carbolic acid to the gallon. The fences should receive a coat of limewash. The feeding troughs and drinking vessels should be put into a kettle of boiling water for half an hour. Troughs too large for this should be burned and replaced by new ones. After these measures are adopted, the longer the premises are left vacant the more likely is the contagion to be completely destroyed. The freezing and thawing of a winter and spring will be found of great assistance. In beginning with a new flock the precautions already mentioned must be adopted to prevent the reinfection of the premises.

TUBERCULOSIS.

The tuberculosis of fowls is a chronic contagious disease, characterized by the development of nodules called tubercles in various organs of the body, but most frequently in the liver, spleen, and intestines. The disease is caused by a bacillus which differs somewhat in its manner of growth in artificial cultures from the bacilli which cause the tuberculosis of people and of cattle. The tuberculosis of fowls is readily communicated to most species of birds and to several species of mammals, but it is almost impossible to communicate the tuberculosis of man and of cattle to fowls. Parrots and the smaller cage birds are very susceptible to human tuberculosis, however, and are often affected by it.

Causation.—Tuberculosis is generally brought into the poultry yard with fowls that are purchased from infected flocks or with the eggs of diseased birds that are obtained for the purpose of hatching. If the disease exists in neighboring flocks the contagion may be carried by small birds or animals passing from one yard to another. A peculiarity of the tuberculosis of birds is that the liver and intestines are nearly always very severely affected, and that as a consequence the bacilli are very numerous in the intestinal contents and are scattered with the droppings everywhere that the fowls go. The introduction of a single diseased bird may, therefore, cause the infection of the greater part of the flock in a few weeks. In the same way, when wild birds contract the disease the bacilli are carried and deposited in all the yards which they visit.

The eggs of diseased birds frequently contain the bacilli, as has been proven by the inoculation of and transference of the disease to rabbits and guinea pigs. The young chicks hatched from such infected eggs are diseased when they leave the shell and, of course, soon infect the poultry with which they run. Moreover, since the sterile incubated eggs are often fed to chickens, it is clear that even the eggs which do not hatch may introduce the contagion unless they are cooked before feeding.

Pigs, cats, rats, and mice are especially liable to be infected with fowl tuberculosis from eating the carcasses of birds which have died, and these animals serve to keep up the contagion and may communicate it to other fowls. Even calves and colts are sometimes found suffering from this form of tuberculosis.

Symptoms.—These are generally not observed in the internal tuberculosis of fowls until the disease has reached an advanced stage of development. They begin with gradual loss of weight, wasting of the muscles, paleness of the comb, and toward the end dullness, sleepiness, and diarrhea. Very often there is at the same time a tubercular inflammation of the joints and of the sheaths of tendons, which is revealed by lameness, swelling of the joints and legs, and sometimes by the formation of hard, external tumors of considerable size. Occasionally the skin over the swollen joints breaks, the interior of the joint is ulcerated, and a small quantity of pus containing large numbers of tubercle bacilli is discharged. Swellings and bony enlargements of the joints with fowls are invariably suspicious, and their nature should always be investigated by killing the bird and examining the liver and spleen to determine if these have any whitish or yellowish spots on their surface which when cut into prove to be tubercular masses.

Treatment.—There is no treatment that will cure fowls which have been attacked with tuberculosis. When the disease is discovered the effort should be to eradicate it at once by killing off the whole flock and thoroughly disinfecting all the houses and runs.

As the great majority of the birds will probably be more or less affected, the chances are that any which are saved will have diseased livers and intestines, from which the bacilli will escape and keep up the infection of the flock and the runs. The danger of this is so great that no attempt should be made to keep any of the fowls that have been exposed to the contagion, no matter how valuable they may be. The bodies of the birds which have died or are killed, as well as all the accumulated manure, sweepings, and scrapings of the poultry houses, should be completely destroyed by fire.

So far as known there is no danger of communicating the disease to man by eating the cooked flesh of tuberculous fowls. In most cases, however, the diseased birds are so emaciated and their general health so affected by fever and diarrhea that their flesh is not fit for human consumption. It is better in all cases to burn the carcasses of the birds in which tubercular nodules are found, and thus avoid all danger of the disease being communicated to either man or animals.

ASPERGILLOSIS.

One of the common molds, called *Aspergillus fumigatus*, sometimes attacks the respiratory or digestive organs of fowls, producing either whitish or yellowish tubercle-like nodules in the tissues or large, flat elevations of a dirty yellow or greenish coloration on the surface of the mucous membranes. Each of the nodules contains a growth of the mold at its center, which is inclosed and imprisoned by a wall of animal cells. The flat elevations, however, represent the free growth of the mold on the surface of the mucous membrane, having very much the appearance which it presents when growing outside of the body on dead organic matter. The greenish color of the diseased area is due to the greenish filaments of the mold or fungus growing upon its surface. The filaments are not all on the surface, however, but they penetrate deeply into the tissues, causing inflammation and swelling, which obstructs the respiration, and at the same time they apparently produce a poison, which causes the general depression and fever. The changes caused by the development of this fungus are most frequently seen in the mouth, the trachea, the bronchial tubes, the lungs, and the air sacs, but they may also occur in the alimentary canal.

Causation.—The *Aspergillus fumigatus* is a very common fungus of great vegetative and resisting powers which is found everywhere growing upon dead organic matter of the most varied kinds. Its development is favored by warmth and moisture, and its spores are often found in enormous numbers in musty or moldy hay, straw, or grain. The mucus on the surface of the membranes, the serum beneath them, and the temperature of the bird's body are all favorable to its growth, while in addition it has the power to resist the efforts of the animal tissues to overcome and dislodge it. Having such characteristics, this fungus is one to be excluded so far as possible from the habitations of poultry, for otherwise it may cause severe and fatal disease.

The spores of aspergillus are most frequently introduced with moldy hay, straw, or chaff that are given to the fowls to scratch in. Often the fungus grows on accumulations of manure, old leather, and similar substances when they are sufficiently moist, and produces spores in enormous numbers. Not all birds are susceptible to its attacks, and it seems to be the delicate breeds and the weak individuals which are most frequently its victims.

Symptoms.—This disease may be limited to a single bird or it may affect a large number. When the air tubes or lungs are attacked the first symptoms are a slight catarrh with accelerated breathing. Soon the swellings obstruct the passage of air and there is a rattling or croupy sound, heard chiefly during expiration. The affected birds mope, separate themselves from the remainder of the flock, remain in a sitting posture; if made to move, it is seen that they are weak and scarcely able to walk, and if they try to run they soon fall from exhaustion. The difficulty of breathing increases rapidly; they gasp for breath and make movements of the head and neck as if choking; there is fever, diarrhea, drooping wings, great depression, a tendency to sleep, and finally suffocation and death.

When the disease is limited to the large air sacs the only symptoms are progressive loss of flesh and weakness. If the small air sacs of the bones are involved, which rarely occurs, there may be lameness, with swollen and inflamed joints. After death the yellowish nodules are sometimes found in the liver and kidneys as well as in the other organs which have been mentioned.

Treatment.—This disease is a most difficult one to cure, but sometimes affected birds may be saved by applying flowers of sulphur or tincture of iodin to the diseased patches seen in the mouth and throat, and causing the birds to inhale the vapor of tar water or turpentine. Tar water is obtained by stirring 2 tablespoonfuls of wood tar in a quart of warm water and letting the mixture stand for a few hours. Then the birds are taken into a closed room, where the tar water is poured, a small quantity at a time, on a hot brick or stone until the atmosphere of the room is well charged with the vapor.

The disease is prevented by giving only clean and bright straw or chaff for the fowls to scratch in, by keeping the houses and yards clean, and using grain and meal for feed which are sound and entirely free from mold. The birds which are sick should be removed from the flock and the bodies of those which die should be burned or buried. The fungus sometimes spreads from bird to bird; consequently the isolation of the sick and the disinfection of the houses should not be neglected.

COCCIDIOSIS.

Coccidiosis is a disease produced by the small forms of animal life called "coccidia." These germs are widely distributed in nature and frequently attack birds and the smaller mammals, such as rabbits, rats, and mice. They are very destructive to young birds, as will be explained in describing the infectious diseases of young chicks, but in this place the description will be limited to the effects of this parasite on adult fowls.

Causation.—Many different species of birds are attacked by coccidiosis, and it is probable that the disease in fowls is always the result of contagion. Pigeons are particularly liable to the disease, and are frequently responsible for the outbreaks in the poultry yards. The transmission of the contagion from diseased to healthy birds occurs by contamination of the food, water, gravel, and other substances taken into the digestive organs. The coccidia multiply with great rapidity in the intestines of diseased birds, and enormous numbers are discharged with the droppings and are carried on the birds' feet to the feed troughs and drinking fountains unless these are well protected and of such form that they can not be reached by the feet. Under any circumstances they are spread over the floor of the houses and the surface of the runs, and many will be picked up with gravel, grain, and other substances. The germs are found in the part of the small intestine nearest to the gizzard, where they cause inflammation, with redness and thickening of the intestinal wall. They are also found in the ceca, which are frequently thickened and distended with a whitish, yellowish, or greenish yellow, pasty mass. After two or three weeks the disease may extend to the liver and lungs, where it is recognized by whitish or yellowish spots or by large cheesy nodules. Geese are attacked by another species, which causes nodules in the kidneys.

Symptoms.—Adult fowls have considerable powers of resistance to this parasite, and the disease with them is more frequently seen in a chronic form. The symptoms are dullness, weakness, sleepiness, diarrhea, and loss of weight, although the birds retain their appetites for a considerable time. In many cases the only symptoms are diarrhea, with loss of weight, and after a time apparent recovery, though the germs continue to multiply in the intestine and to be spread with the droppings for several months afterwards. Fowls affected in this manner may die suddenly without previously showing any serious symptoms.

Pigeons are affected with a more acute type of this disease in which the symptoms appear only a short time before death. Generally, however, they are dull and sleepy for a day or two, and sometimes they have a chronic form, characterized by diarrhea and loss of weight.

Geese with coccidiosis of the kidneys lose flesh rapidly, without apparent cause, and become very weak and almost unable to walk. They remain quiet most of the time, with belly resting upon the ground. Some of them are conspicuous by lying on their backs with their feet widely separated, and if placed upon their feet they take a few steps, fall, and resume the former position. In all such cases the birds lose their appetites and continue to get weaker until they die.

Treatment.—The most successful treatment has been to put 3 grains of copperas (sulphate of iron) to a quart or 15 grains of catechu to a gallon of the water given the birds to drink. They should also be given an occasional dose of calomel (¾ to 1 grain) or of castor oil (2 to 3 teaspoonfuls). They may also be given castor oil containing 5 to 10 drops of oil of turpentine with each dose.

As the coccidia are brought on the premises with birds or eggs for hatching obtained from infected flocks or by pigeons flying from place to place, the necessary precautions should be observed to guard against such channels of infection. Fowls and eggs should be obtained only from flocks known to be healthy, and pigeons should be excluded from the poultry yard.

This form of contagion is very difficult to destroy, and the most active disinfectants should be used. A mixture containing 10 per cent of the compound solution of cresol is none too strong.

The bodies of the birds which die should be burned.

WHITE COMB (FAVUS).

White comb, baldness, or favus of fowls is a contagious disease that begins by the formation of white or grayish spots on the comb, ear lobes, or wattles. These spots are caused by the growth of a fungus called *Lophophyton gallinæ*, and they continue to enlarge, run together, and become more inflamed until all the skin of the head and neck is much thickened, roughened, covered with crusts, and more or less bare of feathers. In extreme cases this inflammation may extend over the skin of other parts of the body, affecting the general health and causing weakness, with, finally, exhaustion and death.

Causation.—This disease is transmitted from fowl to fowl by simple contact and is easily transmitted by inoculation from fowl to fowl. It is most frequently seen affecting common fowls and turkeys, and may be communicated by inoculation to mice and rabbits, but attempts to infect lambs, dogs, rats, guinea pigs, and pigeons have failed. It is also easily inoculated on man, producing large red, scaly patches on the skin, and such patches sometimes develop spontaneously, being no doubt due to contagion from affected fowls.

The filaments of this fungus do not penetrate deeply into the skin, but remain very near to the surface, and consequently the general health does not suffer in the early stages of the disease. It is only when a large area of skin is affected that there are symptoms, such as diminution of appetite, loss of weight, and great weakness, which indicate the absorption of poisonous products. Young birds are believed to be more susceptible than older ones, and some breeds appear to inherit a predisposition to this disease, but no age or breed is entirely exempt from it.

Symptoms.—Favus generally begins on the bare parts of the head as small white or grayish spots, round or irregular in form, which increase in number and size and join together until the whole surface is covered. The affected spots are covered with dry, scaly, dirty-white crusts with an irregular surface, and have an appearance of being formed of concentric deposits. Removing the deposit the skin beneath is seen to be slightly inflamed and abraded. Often the circular spots enlarge regularly and are covered by layers of scales thicker at the periphery than at the center, which gives them a peculiar cup-shaped appearance. As the disease advances the skin becomes thicker, until in the course of a month it may reach one-third of an inch and considerably change the appearance of the head. The neck and body are gradually invaded, the feathers become brittle and break off, leaving a deep depression in the center of a cup-shaped disk. Occasionally the disease is inoculated into the feathered parts of the skin and begins there instead of on the bare parts of the head, but this is exceptional.

The disease when limited to the comb and wattles may disappear without treatment, but after it has invaded the feathered parts it almost invariably continues to advance, and the birds grow weaker until they die from this or some other disease to which their debilitated condition has made them abnormally susceptible.

Treatment.—When only the bare parts of the head are affected the disease may be cured by applying tincture of iodin to the diseased spots. Some recommend an ointment of calomel 1 part, vaseline 8 parts; others prefer a mixture of soft soap 20 parts, carbolic acid 1 part, to be well mixed and applied daily. An ointment of red oxid of mercury 1 part, vaseline 8 parts, is also used, as well as olive oil containing 1 per cent of carbolic or cresylic acid.

It is essential that the affected bird should be separated from the flock, put in a dry, clean place, and given good nourishing food. If the feathered parts of the body are affected, it is better to kill the bird, as the treatment would be long and expensive and there would be danger of the disease spreading.

The disease should be prevented by excluding all affected birds, by burning the bodies of those which die or are killed, and by disinfecting the houses where diseased birds have been.

"GOING LIGHT" (LOSS OF WEIGHT).

"Going light" is a term applied to fowls which persistently lose weight, become emaciated, anemic, weak, and unproductive. Sometimes it is only one or two birds that are so affected, but frequently it is a large part of the flock. Fowls "go light" from different causes;

sometimes it is the result of being severely infested with lice and mites; at other times it is due to intestinal worms; and at still other times to chronic forms of infection with aspergillosis, coccidiosis, tuberculosis, or cholera. When, therefore, the fowls are not thriving, and when lifted appear to weigh little more than should the feathers with which they are covered, an investigation should be made to determine the cause. This should begin with the food supply and it should be ascertained whether the birds have been receiving a sufficient quantity of sound and nutritious food. Then the birds and the houses should be carefully examined for lice and mites. Separate the feathers under the wings, about the vent, and over the rump, and look carefully for these parasites. Then examine the houses, take out the roosts and examine these carefully, especially on the undersides and at the ends; also the woodwork on which the roosts were supported. If no defect is found in the rations, and the birds and houses are free from lice and mites, kill one of the lightest birds and carefully open the intestines for their entire length to learn if the birds are harboring a sufficient number of intestinal worms to account for their condition. A few worms would not have such a pernicious effect; but if there are many they would certainly be partly, and probably would be entirely, responsible for the emaciation. If the fowl is found to have few, if any, parasitic worms, the cause of the trouble is probably a chronic infection with one of the microbes mentioned above.

The treatment of this condition will obviously depend upon its cause. If it is found to be due to insufficient food or food of bad quality, a proper ration must be provided. If it is due to lice and mites or to intestinal worms, these parasites must be combated by the measures elsewhere enumerated. If it results from chronic microbian infection, an effort should be made to overcome this by thorough cleaning and disinfection of the houses, by feeding sour milk or buttermilk with the ration, and by giving an occasional purgative, such as Epsom salts or castor oil. In any event the food must be abundant, the fowls must have plenty of exercise, and the houses must be kept in a dry and sanitary condition.

INFECTIOUS DISEASES OF YOUNG CHICKS.

Young chicks are particularly susceptible to the attacks of the various microbes which cause disease in adult fowls, and the conditions of infection, the symptoms, and the preventive measures to be adopted vary to such an extent that they must be given special consideration.

WHITE DIARRHEA.

This is a condition which has as its most prominent symptom more or less profuse diarrhea, the droppings consisting almost entirely of mucus from the intestinal tube and the white secretion of the kidneys. The diarrhea results from irritation of the intestines and the increased secretion of mucus, while the large quantity of white material secreted by the kidneys is due to fever and rapid breaking down of the elements of the tissues. This condition is most frequently seen with incubator chicks, but is also common with those which are hatched under hens.

Causation.—It has been found by investigation that the white diarrhea of young chicks is caused by at least four different kinds of infection, and each of these needs to be studied separately. All of these microbes also infect adult fowls and are generally communicated directly or indirectly from these to the chicks.

The most common cause of the disease is a bacillus called *Bacterium pullorum.* This often infects hens and also the eggs which they lay. Such eggs produce chicks which have the germs of the disease within them when they are hatched, and these chicks show symptoms within the first few days of their lives. The contagion may also be communicated from chick to chick by means of the microbes scattered with the droppings, which contaminate the food and drink, and cause the appearance of the symptoms when the birds are from 1 to 2 weeks old. The chicks are most susceptible to infection during the first 24 hours of their lives, are more resistant during the second and third days, and are practically insusceptible after the fourth day. Those that sicken later must have taken the microbes into their bodies before they reached that age. Incubators and brooders, as well as coops, become infected and preserve the contagion indefinitely. Adult fowls are resistant to this microbe and do not show any symptoms even when they are laying infected eggs.

The cholera bacillus may also be carried by laying hens and infect the egg before it is laid. The young chicks hatched from such eggs soon show symptoms of disease and communicate the contagion to others at all ages.

The coccidia which cause a chronic disease in adult fowls may also infect the eggs and cause disease with similar symptoms in the chicks.

The aspergillus fungus is the fourth cause of white diarrhea. It occasionally is included in the egg when it is laid, but it may also penetrate the shell when eggs are packed in moldy chaff, straw, or grain, or allowed to get damp.

All of these microbes may also be carried on the outside of the shell, and may infect nest boxes, incubators, brooders, and yards where diseased chickens have been.

Symptoms.—The symptoms of white diarrhea are seen in young chicks which are from a day or two to 3 or 4 weeks old. In the most acute form they may die suddenly after having shown but slight symptoms for a short time. Generally, however, there is first observed a disposition to huddle together and to remain under the hover or under the hen more than young chicks should. Very soon they appear listless, indifferent to what is going on about them, stupid, and sleepy. They stand in one position or sit still with the eyes closed, and the few efforts which they make to pick up food appear mechanical and unsuccessful. Their plumage loses its luster, the wings droop or project slightly from the body, and the characteristic diarrhea soon appears. The droppings which are voided may be white and creamy, mucilaginous and glairy, or they may be mixed with a brownish material. Often the sticky excrement adheres to the downy feathers about the vent, dries, and continues to accumulate until it completely covers and plugs this opening. This condition, known as "pasting up behind," will, unless soon relieved, bring about the early death of the chick.

Many of the diseased chicks chirp or peep almost constantly, and when attempting to void the excrement they may give utterance to a shrill cry, as if the effort brought on paroxysms of pain. As death approaches the breathing becomes labored, and the abdomen heaves with each breath. Often the disease is of a more chronic type and has a longer course. The young birds with diarrhea gradually waste away, become weaker and more emaciated until their legs are scarcely able to support their bodies. They try to brace themselves by standing with the legs apart or they rest against a wall or other object for support. Many of them have the peculiar form of body called "short backed," which results from the distention of the abdomen and its projection backward, which makes the back appear too short for the body. Toward the last the strength is completely exhausted, and the chick sits constantly or lies on the side with outstretched wings until it dies.

The most prominent and characteristic symptoms in nearly all cases are the white diarrheal discharges and the rapid wasting away of the affected birds. The losses vary from 50 to 80 per cent of the chicks hatched. Sometimes it is impossible to raise any of them.

Treatment.—The medical treatment of affected chicks is impracticable, as it is too expensive and has very little effect on the course of the disease. The birds may be given sour milk or buttermilk to drink, or, lacking this, 15 grains of powdered catechu may be added to the gallon of drinking water.

The preventive measures should begin with the eggs used for hatching. If these are purchased they should only be accepted from flocks known to be healthy, and the eggs of which give rise to healthy chicks. If this assurance can not be obtained, it is better to produce the eggs needed for hatching on the home farm and from hens that are known to be free from infection.

Having obtained the eggs, they should be kept until ready for incubation in a dry, moderately cool place, so spread out that the air can circulate over them and carry away the moisture which they exhale. They should not be placed in hay, straw, chaff, or other substance liable to become musty or moldy. Before putting them into the incubator or under the hen they should be wiped with a cloth wet in grain alcohol of 70 to 80 per cent strength to remove any germs that might be on the surface of the shell. The hens used for hatching should be free from all infection and the incubator should be thoroughly cleaned. If there have been any sick chicks in it, it should be disinfected by washing with compound solution of cresol (5 per cent solution). The same precautions should be adopted in regard to the brooder.

If the hatching is done by a hen the brood should be put upon fresh ground, and any chicks which sicken should be immediately removed and isolated or killed. By removing frequently to fresh ground or by frequent disinfection the disease may sometimes be limited to a few individuals.

If the hatching is done in an incubator and there is reason to suspect that the disease may develop, it is well to divide the trays and the brooders by light partitions so that not more than 4 or 6 chicks will be in one lot and exposed to each other. If white diarrhea appears in any of these lots, such lots may be removed and the places which they have occupied may be disinfected. After four or five days the partitions may be removed and the healthy lots of chicks put together. In this way the greater part of the chicks are protected against the most common form of the disease.

BROODER PNEUMONIA.

This is an inflammation of the lungs caused by the growth of the aspergillus fungus in the smaller air tubes and in the lung tissue. It is believed that it may occur from infection carried within the egg. Whether this infection is derived from the hen or from the material in which the eggs have been packed is not definitely known, but the latter method of infection is the more probable. The fact of the lungs being the principal seat of the infection indicates that the spores in most cases are inhaled with the breath and germinate at or near the points where they are deposited. The inference from this method of infection would be that the incubators or brooders, or both, had been allowed to get filthy and moldy, and that the atmosphere in these was filled with aspergillus spores.

The symptoms are very similar to those described as present in white diarrhea, but the breathing is more rapid and difficult and is sometimes accompanied by sounds due to obstruction of the air tubes. The disease is not generally distinguished from white diarrhea, as this symptom (white diarrheal discharges) is usually present in the lung disease as well as in the intestinal infection.

The sick chickens can not be cured, and therefore all the efforts must be directed toward prevention. The measures mentioned for the prevention of white diarrhea are applicable to brooder pneumonia, but if the disease has once occurred among the chicks especial care must be given to the cleaning, disinfection, and drying of the incubators and brooders before they are again used. It is probable that this disease is generally due to failure to maintain a proper degree of cleanliness.

GAPES.

Gapes is a disease of chickens which develops during the first few weeks of their lives and is made evident by frequent gaping. It is caused by a parasitic worm (*Syngamus trachealis*) which attaches itself to the internal surface of the windpipe, sucks blood from the mucous membrane, and obstructs the passage to such an extent as to interfere seriously with the breathing. The insufficient supply of air, the loss of blood, and the diminished activity in looking for food lead to a weak and bloodless condition and often to death from overcrowding or exposure that a well chick would be able to resist without injury. Sometimes so many worms accumulate in the windpipe that breathing becomes impossible and the chick dies from suffocation.

Causation.—The worm which causes this disease is sometimes called the red worm or the forked worm because of its color and of the fact that the male and female are so firmly grown together that they can not be separated without tearing the tissues. The two worms united in this manner appear at first sight like a single worm with two necks and two heads. The female is a little more than one-half inch in length and the male one-fifth inch. The heads of both are attached to the mucous membrane, irritating it to such a degree that there is an increased secretion of mucus, which collects and increases the difficulty of breathing.

A large number of eggs develop in the female worm while in the windpipe, and these are either thrown out by the chick while sneezing or they are swallowed, pass through the stomach and intestines unharmed, and are scattered with the droppings. These eggs adhere to the food or get into the drinking water and thus infect other chicks and keep up the disease indefinitely. Often the red worms are coughed up, but they are immediately seized and swallowed by some of the chicks, and in this manner also the disease is spread.

The eggs of this worm live a long time in the soil and are sometimes taken into the digestive tube of earth worms. In badly infested ground a considerable proportion of the earthworms may, if eaten, be capable of causing the disease in chicks.

These facts explain why ground upon which chickens are raised year after year becomes so badly infested, and how the infection is carried over from one year to the next. It seems that the worms may also be carried by grown fowls and by some wild birds and that this is another means for their preservation.

When the eggs of this worm are taken into the stomach of the chicks the young worms are soon liberated and find their way in a few days to the windpipe, where they may be seen already attached within a week.

Symptoms.—The symptoms of gapes are most frequently observed in chicks from 10 days to 4 weeks old. The affected birds cough or sneeze with an abrupt, whistling sound and a more or less labored effort. Very soon they begin to gape, extending the neck and opening the beak, thus indicating that they are not getting a sufficient supply of air. During the first few days the appetite is ravenous, but in spite of the quantity of food eaten the birds become weak, anemic, and emaciated. Later there is little appetite, the affected birds are dull, have difficulty in keeping with their companions, and as the disease advances their wings droop and they stand with closed eyes and head drawn back into the body. Frequently the head is thrown forward and they gape or give it a convulsive shake in order to loosen the obstruction in the windpipe and permit the entrance of air. In this condition they are liable to die suddenly from suffocation, from exhaustion, or from being trampled by their fellows at night.

The most vigorous and the older birds show only mild symptoms or none at all. They may gape occasionally, but their appetites remain good and they continue to grow. However, as the soil becomes more and more intensely infested the proportion of the chickens which are able to resist the attacks of these parasites becomes less, until finally it may be almost impossible to raise either chickens or turkeys.

Treatment.—Reliance must be placed upon prevention rather than cure, because a chicken 2 to 3 weeks old has not sufficient value to warrant the expenditure of much time or medicine in its treatment.

Sometimes it is found advisable to extract the worms or to inject some liquid into the windpipe which will kill them. Extractors are made in various ways. Generally a small quill feather is stripped of all of its web except a small tuft at the end, and this is used either dry or moistened with kerosene or oil of turpentine. A fairly good extractor may be made by taking a hair from a horse's tail, bending it in the middle, and twisting the two ends together so as to form a loop; or a similar loop may be made by cutting the hair, laying the two pieces side by side, tying a knot near the end, trimming the short ends close to the knot, and twisting the long ends together. These homemade extractors have been imitated in the poultry-supply trade by doubling and twisting a small flexible wire which carries a few moderately stiff hairs to scrape off the worms.

These extractors are all used in the same manner. The chicken's beak is forced open with the thumb and fingers of the left hand, while the extractor is held in the right hand. When the glottis, which is a small aperture at the root of the tongue, is opened for breathing, the extractor is carefully inserted and pressed downward into the windpipe. The neck should be kept extended in a straight line, so that the extractor will enter freely and not injure the delicate walls of the windpipe. At the first insertion the loop or brush should not pass more than an inch below the glottis; then it should be given two or three turns between the thumb and finger and withdrawn. If any worms adhere to it, these should be dropped into a basin of hot water or kept and burned. The extractor may now be inserted a little deeper, and so on until it reaches nearly the full length of the neck. If the slightest resistance is felt to the entrance of the extractor, it should not be pressed upon or inserted any farther. In all cases the extractor must be quickly withdrawn to avoid suffocating or otherwise injuring the chicken. Often 8 or 10 worms may be removed in this manner, and if the treatment has not been so rough as to cause injury the symptoms will be very much improved.

Recently good results have been reported from medicating drinking water with 15 grains of salicylic acid or 3 drams of salicylate of soda to the quart of water, and in Germany the disease is said to be successfully treated by introducing a small soft-rubber tube into the windpipe, in the same manner as described for an extractor, and injecting 3 to 10 drops of a 5 per cent solution of salicylate of soda.

The best method of prevention is to put the chicks, when hatched, on fresh ground; to remove, place in a separate coop, and treat any that show symptoms, and to plow and seed down the old, infected runs, not permitting chickens to go upon them for two or three years.

WORMS.

Sometimes the fowls of a flock become badly infested with worms, which live in the crop, stomach, and intestines and either cause serious disease or affect the nutrition, so that the birds become weak, bloodless, and unproductive. The nature of the condition is determined by examining the birds that die, or by killing one that is very thin and weak. The intestines, the stomach, and the crop should be opened and their contents carefully examined. If a considerable number of roundworms or tapeworms are found, the remainder of the flock should receive appropriate treatment.

Treatment.—The remedies which are used to dislodge these parasites should be given when the birds are fasting. They should have a light feed at night and should be given the medicine the following morning. Two or three hours after giving the medicine they should have a purgative, which may be Epsom salts, 40 grains for each adult bird thoroughly mixed with a small quantity of moist mash and so distributed that each bird will get its share, or they may be given 2 to 3 teaspoonfuls of castor oil. An hour later a light ration may be given.

One of the best remedies is oil of turpentine, which may be mixed with an equal quantity of olive oil and 20 to 30 drops of the mixture given at a dose. This is followed in two hours with 2 to 3 teaspoonfuls of castor oil.

Thymol is especially active in the case of roundworms, and 1 grain of it may be made into a pill with a little bread and butter and given to each fowl. It should be followed by a purge, as in the case of other remedies. Santonica or worm seed in doses of 7 or 8 grains is also successfully used to combat this class of worms.

The remedies which are particularly efficacious for tapeworms are powdered areca nut, 30 to 45 grains; powdered male fern, 30 to 60 grains; kemala, 30 to 40 grains for each fowl. These are followed by Epsom salts, castor oil, or calomel (one-third grain). Areca nut, male fern, and kamala may produce bad effects in turkeys and geese, and must be given to these birds in comparatively small doses.

Preventive treatment must be carried out at the same time as the medical treatment or the birds will be immediately reinfested by eggs or embryos of worms taken with the food or drink. Ponds or puddles of stagnant water should be drained or filled with earth; houses and runs (if small) should be cleaned and disinfected with 5 per cent cresol solution; feeding troughs and drinking vessels should be cleaned daily and disinfected with the same cresol solution or with boiling water; the manure should be collected daily, mixed with an equal quantity of freshly slaked lime, and put where the fowls will not have access to it.

It is considered preferable by some poultrymen, in the case of a badly infested flock, to kill off all the birds and begin a new flock on fresh ground with chickens hatched in incubators or with fowls from a flock known to be healthy.

MANGE (SCABIES).

Fowls and pigeons are affected by scabies, but the disease is not communicated from pigeons to fowls, nor vice versa, as the parasitic mites are not identical.

Causation.—The mites which cause the disease are introduced into the poultry yard by affected fowls, and they spread rapidly from fowl to fowl until nearly or quite all of the birds are affected. The mite lives at the base of the feathers, where it bites the skin and causes intense itching.

Symptoms.—This form of mange is often called depluming scabies on account of the rapid destruction of the feathers. It generally begins in the spring, is most active during the warm weather, and disappears in winter. The most prominent symptom is a loss of feathers from spots of various sizes on different parts of the body. It usually begins on the rump and spreads rapidly to the back, thighs, breast, neck, and head. As the mites progress from the starting point over the surface of the body their advance is indicated by the falling of the feathers, until finally the fowl becomes nearly naked, the large feathers of the tail and wings being all that remain.

The skin which is bared in this manner is smooth, soft, and little if any changed by the disease. However, if the stumps of the feathers are examined soon after the breaking of the quill they are found surrounded by scales and crusts, and by pulling out the adjoining feathers they are seen to be similarly affected.

The irritation produced by this mite leads the fowls to pull out their feathers, and they often acquire the habit of feather pulling, attacking the plumage of other birds as well as their own. Depluming scabies is often mistaken for the vice of feather pulling or for irregular molting. Usually the general health of the affected birds does not suffer greatly, but if the disease is allowed to continue untreated some of the hens lose flesh and become unproductive, while the males may show great weakness and anemia.

Treatment.—Apply to the affected spots of the skin and for some distance around them an ointment made by thoroughly mixing 1 part of flowers of sulphur with 4 parts of vaseline or lard, or 1 part of carbolic acid with 50 parts of vaseline. A convenient liquid preparation is made by mixing Peruvian balsam 1 ounce, alcohol 3 ounces. One of these preparations should be selected and applied at least twice with an interval of about a week. A good lice powder should be applied to all of the fowls a day or two before beginning the other treatment, and at the same time that the latter is applied the houses should be thoroughly cleaned and disinfected.

SCALY LEG, MANGE OF THE LEG.

This condition is caused by a mite of another species from that which causes mange of the body. It affects fowls, turkeys, pheasants, and cage birds. While usually it does not affect the general health of the birds, it gives them a very unsightly appearance and is an indication of neglect and bad management on the part of the owner. The disease occurs only by contagion from other birds; it spreads very slowly, and many individuals escape it entirely, although constantly exposed to it.

Symptoms.—The disease is easily recognized by the enlargement of the feet and legs and the rough appearance of the surface caused by the loosening and raising of the scales on the legs and the upper surface of the feet. This parasite begins its attack in the clefts between the toes and gradually spreads forward and upward until the whole of the foot and shank becomes affected. The two legs are usually attacked at the same time and about to the same degree. At first there is seen only a slight roughening of the surface, but the continued irritation by the mite causes the formation of a spongy or powdery substance beneath the scales which raises them more and more, until they are nearly perpendicular with the surface and are easily detached. In the most severe cases the joints become inflamed, the birds are lame and scarcely able to walk, a joint or an entire toe may be lost, and the birds, unable to search for food, lose flesh and die from hunger and exhaustion.

Treatment.—Wash and brush the legs with soap and warm water, removing the loose scales that come off without causing bleeding. Dry the legs and apply a coating of balsam of Peru or an ointment containing 2 per cent of carbolic acid. A remedy highly recommended is made by mixing 1 part of oil of caraway with 5 parts of vaseline. When large numbers of fowls are to be treated, some poultrymen make a mixture of one-half pint kerosene and 1 pint raw linseed oil in a quart can, take this to the poultry house at night, and dip both legs of each affected bird into the mixture, allowing them to drip into the can for a minute after removal, and then replacing on the roost. The feathers of the leg must not be wet, as this causes irritation and sometimes burns the skin. The treatment should be repeated in three or four days.

CROP BOUND, IMPACTED CROP.

This is an overdistended and paralyzed condition of the crop, generally caused by overeating or by swallowing coarse and indigestible substances, such as feathers. In cholera the crop is paralyzed as a result of the disease.

Symptoms.—The first symptom is a loss of appetite or an effort of the bird to swallow without being able to do so. The crop is seen to be very large and much distended with contents which are more or less firmly packed together. If permitted to continue, the condition becomes aggravated, the breathing difficult, and death may result.

Treatment.—The contents of the crop may sometimes be removed by forcing the bird to swallow a teaspoonful or more of sweet oil, then massaging the lower part of the gullet, if it contains food, or, if not, the part of the crop nearest to the gullet, until a part of the contents are softened and may be pressed toward the head. This is made easier by holding the bird head downward. By continued manipulation the greater part of the material may be removed. The bird should not be permitted to eat for several hours after it is relieved.

If this plan of treatment is not successful, the crop must be opened with a sharp knife and the contents removed through the opening, using for this purpose a coffee spoon, a button hook, small forceps, a bent wire, or other suitable instrument. After this is done, wash out the crop with clean, warm water. The opening should not be over an inch in length and should be closed with 3 or 4 stitches first in the wall of the crop and when this is finished an equal number in the skin. Each stitch should be made and tied separately. Coarse white silk is the best material, but if it is not at hand ordinary cotton thread may be used.

Feed on milk and raw egg beaten together for a day or two, and gradually change to soft mash.

INFLAMMATION OF THE STOMACH OR INTESTINES.

This trouble, when not the result of one of the contagious diseases to which reference has been made, is generally due to eating moldy or putrid food or irritating mineral poisons. It is indicated by loss of appetite, dullness, and constipation or diarrhea. It may be treated by giving 30 or 40 grains of Epsom salts or 2 teaspoonfuls of castor oil, and feeding a soft mash for a day or two.

LIMBERNECK.

The condition known as "limberneck" is in reality not a disease but is a symptom of several diseases which are characterized by a paralysis of the muscles of the neck, which makes it impossible for the bird to raise its head from the ground. This condition is due to the absorption of poisons from the intestines, which act upon the nervous system and cause paralysis. It is generally associated with indigestion, or the eating of moldy grain or putrid meat or with intestinal worms. The best treatment is to give a full dose of purgative medicine; that is, 50 or 60 grains of Epsom salts or 3 or 4 teaspoonfuls of castor oil for a grown fowl. Often the birds will be cured within 24 hours, and in case they are not better within 3 or 4 days it is not advisable to keep them.

LIVER DISEASE.

When not produced as the result of one of the contagious diseases described elsewhere, liver disease is generally caused by errors of feeding and lack of exercise. It can not certainly be distinguished from other forms of disease during the life of the bird. When examined after death the liver is found enlarged and so tender that it is easily torn. If it is suspected that other birds in the flock are similarly affected, correct the ration, give plenty of green feed, and encourage exercise in the open air.

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FARMERS' BULLETIN 531.

LARKSPUR, OR "POISON WEED."

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief.
Washington, D. C., March 10, 1913.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin the accompanying manuscript, entitled "Larkspur, or 'Poison Weed,'" prepared by Dr. C. Dwight Marsh and Mr. A. B. Clawson, Physiologists, and Hadleigh Marsh, Laboratory Assistant, Poisonous-Plant Investigations, under the direction of Dr. R. H. True, Physiologist in Charge of the Office of Drug-Plant, Poisonous-Plant, Physiological, and Fermentation Investigations of this Bureau.

A detailed account of the experimental work on larkspur poisoning has been prepared. The demand for immediate information on this subject is so great, however, that it is deemed wise to issue in an abbreviated form the most important practical results of this investigation.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. D. F. Houston,
Secretary of Agriculture.

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LARKSPUR, OR "POISON WEED."

INTRODUCTION.

The larkspurs have been known to be poisonous from the time of the ancient Greek and Latin writers to the present. It is only in North America, however, that they have been important as causing losses of stock. The recorded losses in North America have been almost entirely in the cattle ranges of the western United States and Canada, although isolated instances of poisoning are known in the eastern mountains. In the cattle ranges of the West probably no poisonous plants, with the exception of the loco weeds, have caused such heavy losses to the stockmen.

It is difficult to estimate with any degree of accuracy the extent of these losses. A conservative estimate based on reports from a large number of ranges indicates that the annual loss is from 3 to 5 per cent. A great many of the stockmen who have reported upon this subject have given an estimate of 5 per cent. Specific cases are known where from 20 to 50 cattle have died out of a single herd within a few hours, and other instances are recorded in which individual stockmen have lost as many as 200 head in a season. These are losses which are attributed to larkspurs, since they have occurred on ranges where the larkspurs are abundant. In most cases, however, definite evidence that the larkspurs were the cause of the losses is wanting. The animals are found dead in localities where they can obtain the plant, and it has been assumed that death was caused by eating these weeds.

A definite belief has been developed among the stockmen of the West that the larkspurs are poisonous, and the symptoms of larkspur poisoning have been described with great uniformity. Accounts of these losses have come from practically all of the cattle ranges in the mountains from the Rocky Mountains west. These ranges at the present time are very largely in the domain of the national forests, and a map of the national forests would give a fair idea of the distribution of larkspur poisoning.

LARKSPURS OF THE WESTERN UNITED STATES.

Two general groups of larkspurs are found on these ranges—the tall and the low larkspurs. The tall larkspurs grow in great abundance in the gulches and canyons of the more elevated cattle ranges, while the low larkspurs grow in similar regions, but upon the open hills and in drier localities.

In the regions where these plants are abundant they are commonly known as "poison," "poison weed," or "cow poison." In New Mexico the tall larkspurs are known as "peco."

TALL LARKSPUR.

In the mountains of Colorado the tall larkspur is represented by the species *Delphinium barbeyi.* This grows from an altitude of about 8,000 feet to very near the timber line. When full grown it is from 3 to 7 feet in height, with a long woody root. The violet-blue flowers are in a dense terminal raceme. The plant starts growth early in the spring and in the region of the experiment station at Mount Carbon was from 1 to 2 feet high in May, forming bunches much more prominent than the grass and doubtless attractive to grazing animals. Figure 1 shows the plant as it appears in May before blossoming, and

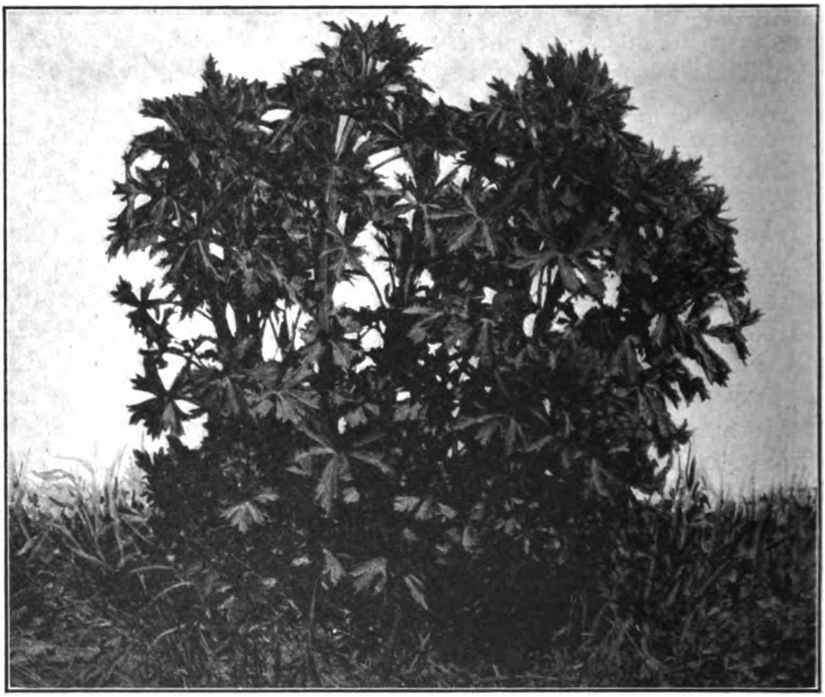

FIG. 1.—Tall larkspur (*Delphinium barbeyi* Huth) before blossoming.

figure 2 shows it in full bloom. It blossoms in July, the seeds are formed in August, and then it commences to dry up, but does not entirely disappear until broken down by the winter snows. This species is found in the mountains of Wyoming and Utah as well as those of Colorado.

The species found in Montana is *Delphinium cucullatum*. It is not so large as *Delphinium barbeyi*, and the flowers present a grayish blue appearance, as the sepals are gray, but the general habit of the plant resembles that of the tall larkspur of Colorado. In the other mountain ranges of the West the species of tall larkspur resemble these species very closely.

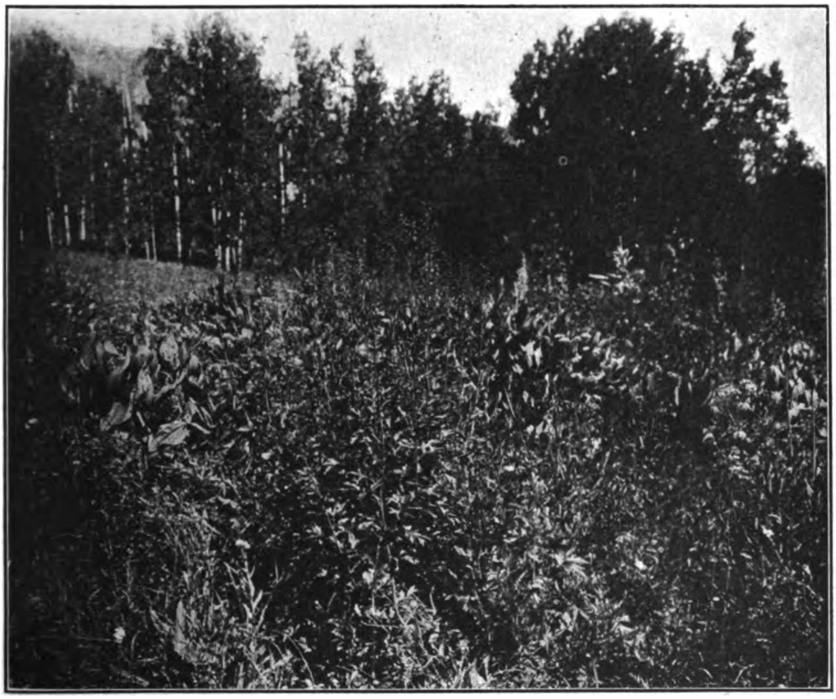

FIG. 2.—Tall larkspur (*Delphinium barbeyi* Huth) in full bloom.

It is not difficult to distinguish the tall larkspur after it blossoms, as no other plant growing in similar localities has a flower at all resembling it. In the early stages, however, like that represented in figure 1, it is easily confounded with geranium and aconite, which frequently grow in great abundance in the same places. Figure 3 shows a plant of geranium (*Geranium viscossissimum* F. and N.) which may be considered a type of the species of geranium which are common in the mountain ranges. The leaves of this geranium resemble those of the tall larkspur. The plant, however, has a very different habit and after blossoming is readily distinguished from the larkspur.

It is more difficult to distinguish the plant of the aconite, an illustration of which is given in figure 4. The plant shown, *Aconitum columbianum* Nutt., may be considered as typical of the aconites found in the mountain regions. Aconite, or monkshood, has a flower easily distinguished by its form from that of the larkspur, as will be seen by comparing figures 4 and 5. While the color of the flower is deep blue instead of violet blue, as in the larkspur, the leaves resemble those of the larkspur, although they are more closely attached to the

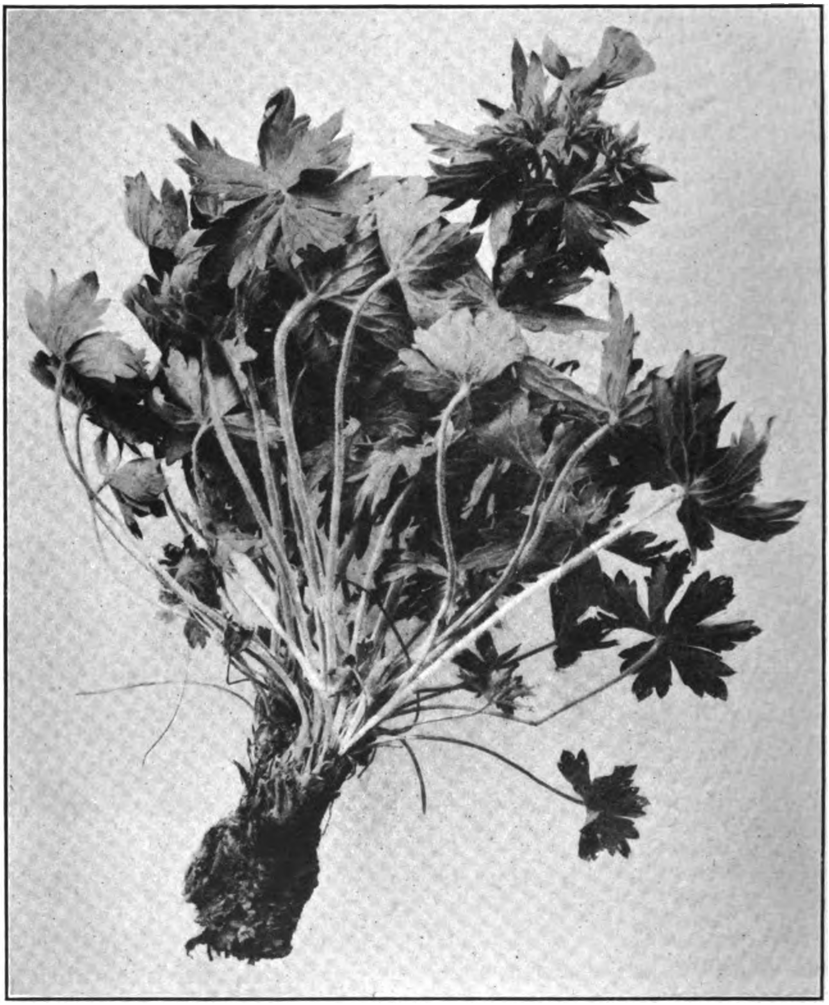

FIG. 3.—*Geranium viscosissimum* F. and N.

stem. The root of the aconite is short and bulblike instead of long and woody, as in the tall larkspur. These aconites frequently grow in considerable abundance in the midst of clumps of the tall larkspur.

LOW LARKSPUR.

Delphinium nelsoni may be taken as a type of the low larkspurs. This species (fig. 5) grows in considerable abundance in Wyoming, Colorado, New Mexico, and Utah, and this or a closely allied species grows in California and Oregon. It is found at altitudes of 4,000 to 10,000 feet on open hillsides and in parks, sometimes covering large areas. The root is short and tuberous, and the plant does not exceed a foot in height. The blossoms, which are violet blue and arranged in a loose raceme, appear in May, and seeds are formed in

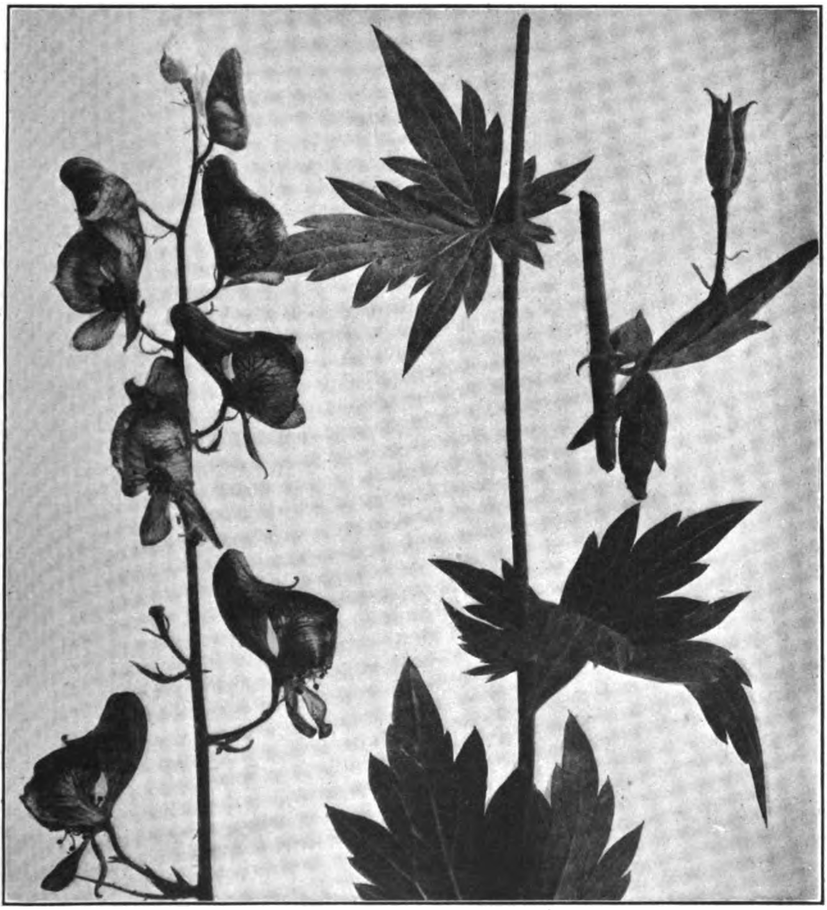

FIG. 4.—*Aconitum columbianum* Nutt.

the latter part of June, after which the plant dies and disappears. The species illustrated is rarely found after the first of July.

In the States north of Colorado a similar larkspur is found, known as *Delphinium bicolor* Nutt. This very closely resembles *Delphinium nelsoni* and has the same general habit of life. The root, however, is long and fibrous, and the blossoms are somewhat larger. It is the most beautiful of the American larkspurs.

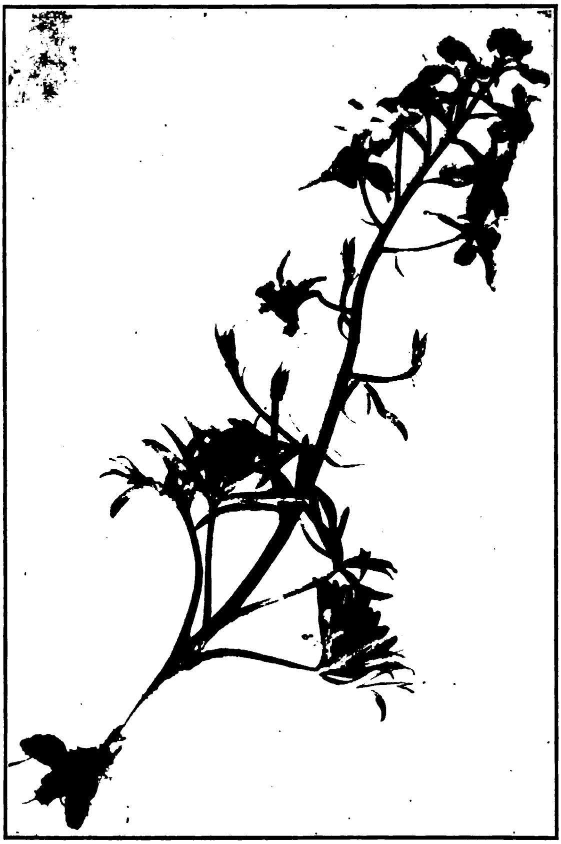

FIG. 5.—Low larkspur (*Delphinium nelsoni* Greene).

SYMPTOMS OF LARKSPUR POISONING.

The first symptom of larkspur poisoning, as noticed on the range, is ordinarily the falling of the animal. When a bunch of cattle is being driven it sometimes happens that one or more will suddenly fall and commence to kick convulsively. In the experimental poisoning it was found that this falling was preceded by a lack of appetite and general uneasiness, with a stiff and staggering gait. When the animal falls it ordinarily goes down very suddenly, the legs appearing to crumple up under it. In the lighter cases of poisoning the animal will hold its head erect and after a longer or shorter time will get upon its feet, only to fall again shortly. In more acute cases the animal lies upon its side with the feet extended more or less rigidly. In these cases it is entirely impossible for the animal to get upon its feet immediately. Occasionally it will fall once, remain upon the ground a short time, and then walk off as if nothing were the matter. More frequently the fall is repeated a number of times. If the animal is hurried after being upon its feet the symptoms of poisoning will be more severe. When a bunch of cattle has been feeding upon a larkspur range and is started up suddenly it is not unusual for one or more of them to fall as the result of the larkspur poisoning. While the motions of the animal when down may be described as convulsive, it can hardly be said that the poison produces convulsions. The kicking seems to be due largely to attempts to rise rather than to involuntary contractions of the muscles of the legs.

Poisoned animals are almost always constipated and usually recover if this condition is relieved. In all severe cases the animals are nauseated and death frequently results from the contents of the first stomach getting into the windpipe. Bloating occurs in some cases, but not in all. When the cattle bloat, death in some cases is doubtless the result of mechanical obstruction of breathing. When the poisoning is sufficiently severe to produce fatal results death ordinarily occurs in a very short time. The symptoms of poisoning by the tall and low larkspurs are the same, and, so far as known, all the larkspurs of the West produce similar symptoms.

EFFECT OF LARKSPUR POISONING UPON ORGANS OF THE BODY.

Cattle fatally poisoned with larkspur bloat almost immediately after death. The autopsies show more or less inflammation of the stomach, of the small intestine, and of the lining of the windpipe. In most deaths from larkspur poisoning more or less of the contents of the first stomach will be found in the windpipe and in the bronchial tubes. The blood vessels of the surface of the body are greatly congested, and the kidneys ordinarily show extreme congestion. Death results from paralysis of respiration, the heart continuing to beat for an appreciable time after respiration has ceased.

PERIOD DURING WHICH POISONING OCCURS.

The low larkspur, as has been stated, is poisonous during the whole of its life, but the plant disappears the last of June or early in July. Poisoning from eating it occurs, therefore, only in the months of May and June. The tall larkspur grows through the entire season, and as it matures the leaves lose their poisonous properties, so that after the middle of August they cease to be poisonous. The seeds are more poisonous than the leaves, and occasionally cattle die rather late in the season from eating them. The loss from eating seeds, however, is very small.

Inasmuch as the tall larkspur plants are particularly attractive to animals before the blossoms are formed, it follows that the most dangerous period of the tall larkspur corresponds very closely to that of the low larkspur, the larger number of cases of poisoning occurring in the months of May and June. Some animals may be poisoned in July, but such cases are comparatively rare. After the middle or last of August cattle eat the leaves of the tall larkspur with considerable eagerness and with no harm whatever. During the season when poisoning occurs apparently all parts of the plants above the ground are poisonous. The roots of the tall larkspur are never eaten by cattle, as they can not get at them. Contrary to the common belief of cattlemen, very few of the roots of the low larkspur are ever eaten by cattle, and the danger is not from the roots but from the parts of the plant growing above ground.

QUANTITY OF LARKSPUR NECESSARY TO POISON.

Small quantities of both the tall and the low larkspurs can be eaten with impunity. Experimental work shows that an animal must eat about 3 per cent of its weight before being affected, and that average cases eat from 8 to 9 per cent of their weight.

POISONING OF HORSES.

Experimental work showed that horses are poisoned by larkspur if they eat a considerable quantity. On the open range, however, it appears that horses never eat enough of the plant to produce any effect, so that horses can be grazed with impunity upon ranges which would be fatal to cattle.

POISONING OF SHEEP.

Careful and extended experiments upon the tall and low larkspurs growing about the Mount Carbon experiment station in Colorado showed conclusively that sheep can graze upon these plants without any harm. Corral feeding experiments showed that sheep can eat very large quantities of larkspur not only without harm but with apparent benefit. The experimental work at the Greycliff station in Montana corroborated that in Colorado, and there is every reason to believe that sheep are never injured by feeding upon the larkspurs.

TREATMENT.

It is of course best, if possible, to avoid larkspur poisoning by handling stock in such a manner that they will not get at the plants in any quantity. No hesitation need be felt in ranging horses and sheep on areas infested with larkspur. Cattle can eat considerable quantities without harm, but it is always dangerous to permit them to graze freely upon a larkspur area. This has been recognized by the stockmen on some of the ranges, who by keeping their cattle from the infested area until about the first of July prevent losses. This can be done either by riders, as in some sections, or by the aid of drift fences. In some cases, where limited areas are particularly infested with these plants, it may be desirable to fence them in and keep the cattle out. In some areas, where the plant grows in great abundance in gulches frequented by cattle, it is entirely practicable to dig out sufficient of the tall larkspur so that the animals can graze in those regions with impunity. Where the tall larkspur grows widely scattered over a range it is impracticable to destroy it by digging. It is well known by stockmen, however, that some gulches are veritable death traps for their cattle, and in those places it would be a matter of economy to go over the area and destroy most of the plants of the tall larkspur before the cattle are admitted.

MEDICINAL REMEDIES.

When cattle are grazing freely upon a range containing larkspurs and are not immediately under the supervision of riders, deaths from larkspur can not be avoided. In cases, however, where the poisoning occurs, as frequently happens, while animals are being driven from one range to another and are under the control of riders, it is sometimes possible to apply remedies which will aid recovery. Many of the cases in which poisoning is not severe will recover if care is taken to turn the animal after it falls, so that the head will be higher than the rest of the body, and to see that it is not further disturbed. Any attempt to get the animal upon its feet or to drive it rapidly is almost certain to be followed by fatal consequences. If the animal bloats badly it should be relieved by paunching, that is, thrusting a trocar into the rumen in the manner which is practiced by so many of the stockmen of the West. It is not clear that bleeding produces any good effects.

When the animal is very weak, subcutaneous injections of 20 cubic centimeters (6 drams) of whisky will aid in bridging over the period of weakness and sometimes save the animal. In all cases it was found in the station work that beneficial results were obtained by using a subcutaneous injection of the following formula:

Physostigmin salicylate	1 grain.
Pilocarpin hydrochlorid	2 grains.
Strychnin sulphate	½ grain.

This formula would apply to an animal weighing 500 or 600 pounds. For a large steer or a cow of 1,000 pounds or more the dose should be twice that given in the formula. These materials can be obtained from any dealer in drugs. The physostigmin salicylate and pilocarpin hydrochlorid are furnished in veterinary hypodermic tablets, each containing one-half grain of physostigmin salicylate and 1 grain of pilocarpin hydrochlorid. The strychnin sulphate can be obtained in tablets each containing one-half grain. These dissolve readily, and it is well to have two or three doses ready in small homeopathic bottles. For yearlings one should use two of the physostigmin pilocarpin tablets and one of the half-grain strychnin tablets dissolved in enough water to half fill an 8-dram homeopathic bottle; for full-grown cattle four of the physostigmin pilocarpin tablets and two of the strychnin tablets dissolved in an 8-dram bottle full of water should be used.

It is best to use an all-metal hypodermic syringe. This can be easily cleaned by boiling. The form which has been found most useful for the field is that known as the Quitman syringe. In this the needles are carried in the hollow piston, and a case is therefore unnecessary. The syringe should be of the 10-centimeter size, which holds half an 8-dram bottle of water, so that the remedy can be given to yearlings in a single dose, while for mature cattle the syringe must be filled twice. The needle is most conveniently inserted in the shoulder.

Stockmen at the present time are accustomed to the use of a hypodermic syringe, and if they are willing to try this remedy can without doubt save the lives of most of the animals poisoned during drives or round-ups. This remedy relieves the condition of constipation and stimulates the respiration.

If it were possible to insure free action of the bowels before cattle were driven over a "poison area," probably most of the poisoning would be prevented. Experimental work is being carried on with the view of accomplishing this result in specific cases.

PASTURING SHEEP ON PRESENT CATTLE RANGES.

It is evident that ranges which are particularly harmful to cattle may be used with impunity for the pasturage of horses or sheep. It is suggested that certain ranges where the losses of cattle have been extremely heavy may profitably be changed to sheep ranges; or it may be possible to graze sheep upon the larkspur areas, and thus avoid the danger of loss to cattle. On some ranges it might be well to graze both cattle and sheep under the same ownership.

SUMMARY.

(1) While the investigations outlined in this bulletin were carried on mainly in Colorado and apply more particularly to the larkspurs of that State, conditions in the other Western States with mountain cattle ranges are very similar.

(2) The tall and the low larkspurs cause the loss of a great number of cattle in the mountain ranges of the West.

(3) These losses occur almost entirely in the months of May and June, although some may occur in the early part of July.

(4) Horses and sheep are not injured by grazing on larkspur areas.

(5) Poisoning may be largely prevented by keeping cattle away from the poison areas until about the end of the first week of July.

(6) Cattle poisoned by larkspur should be kept as quiet as possible, should be paunched if bloating occurs, should not be bled, and may in many cases be saved by a subcutaneous injection of physostigmin salicylate, pilocarpin hydrochlorid, and strychnin sulphate.

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FARMERS' BULLETIN 532.

Experiment Station Work,

LXXV.

Compiled from the Publications of the Agricultural Experiment Stations.

GARDEN SWEET PEAS.
WINTER-FLOWERING SWEET PEAS.
SOUTHERN BUR CLOVER.
TYPE OF SHEEP FOR SOUTHWEST
COMBATING FLIES.

MARCH, 1913.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS
A. C. TRUE, Director.

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[1] Director. [2] Special agent in charge. [3] Acting director.

EXPERIMENT STATION WORK.

Edited by W. H. BEAL and the Staff of Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

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EXPERIMENT STATION WORK.[1]

GARDEN SWEET PEAS.[2]

The sweet pea can adapt itself to a variety of locations, but a position which provides for plenty of light and air at all times with a little shade from the midday suns of July and August is to be preferred. Plants grown in too much shade are usually weak and spindling with but few flowers. The drying summer suns tend to shorten the blooming period and also cause certain colors to fade. The effects of drought can be largely overcome, however, by early planting and by deep and thorough preparation of the soil. In seasons when the conditions are especially favorable sweet peas can be grown with fairly good results with no more preparation than is given ordinary vegetable ground, but as A. C. Beal writes in a recent bulletin of the Cornell station, " uniformly, year after year, the sweet peas with the strongest root systems will produce the finest flowers during the longest period." Vigorous root development can best be secured by planting just as early in the spring as the soil is dry enough to work, while the atmospheric conditions are such as to retard or even to prevent top growth for several weeks.

Any ordinary garden soil is suitable for sweet peas, providing it is well drained. Since sowing should be done at the earliest possible date, the soil should preferably be prepared in the autumn.

> The soil should be broken up to a depth of 15 inches to 2 feet, and on some soils even deeper. Unless the soil is very uniform in composition, it is disastrous to bring the bottom soil to the surface; but this should be turned over in the trench, mixing with it, if heavy and compact, rather coarse stable manure or litter. Sometimes leaves are available for placing in the bottom of the trench. The use of these materials in subsoil promotes drainage, as well as improves the soil.
>
> If a good layer (4 inches) of half-rotted stable or cow manure is placed between the top and bottom spadefuls, and the top soil, if heavy, made light with old manure, an excellent preparation has been made. The office of the manure is not only to increase the store of plant food, but also to increase the water-holding power.

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[1] A progress record of experimental inquiries published without assumption of responsibility by the department for the correctness of the facts and conclusions reported by the stations.

[2] Compiled from New York Cornell Sta. Bul. 320.

An application of bone meal at the rate of 1 ounce per yard of trench, as well as a good dusting of air-slaked lime applied while working the soil in the autumn will both prove beneficial. The lime will not only correct any acid condition existing in the soil, but it will also aid in releasing the residual plant food of the soil.

Certain white-flowered sweet peas have light-colored seeds, while others have black seeds. The white seeds frequently split in the pod before harvesting and are likely soon to lose their vitality if planted early when the soil is cold. Hence the white seeds should be sown rather thicker than, or not so deep as, the black seed. In the sweet-pea plantings at Cornell it has been found that an ounce of seed will plant 50 to 60 feet of row, and if the seed is good it should plant still more. This allows for one seed to every 2 inches.

In some seasons sweet-pea seeds are slow in germinating. It is well to examine such seeds in order to ascertain their condition. If the seeds are found dormant but still fresh and plump, the seed coats should be cut with a sharp knife and replanted, when they will germinate well. This difficulty is not confined to the sweet pea, but some of the other Lathyri behave similarly. The trouble usually follows a very hot, dry season, when the seed becomes so excessively ripened as to render the seed coat impervious to water. Sometimes, in order to expedite germination, the seeds are soaked; a better method for the amateur is that recommended by Mr. Hutchins, the most prolific writer on sweet peas in America, who places the seed packets in moist earth for seven or eight days, then takes them out and examines them. The swollen seeds are planted, and the others cut with a knife.

In a test conducted at Cornell in 1909–10 the best results were secured from fall-planted seed. When to sow the seed in the fall will depend largely upon seasonal conditions in the locality. The ideal to be attained is to sow the seed long enough before freezing weather sets in to permit the roots to develop, without at the same time starting the leaves into active growth.

Fall planting.—In the season under discussion the finest and the earliest flowers were secured from plantings made in the fall. The preparation of the soil is the same as that already described, except that the soil is firmed and the trench filled level. On this a trench, or furrow, 2 inches deep is made, and the peas are planted at least as close as one seed every 2 inches. The row should be slightly ridged up so as to prevent water from standing and, as stated in the beginning, it is essential that the location be on a well-drained site. When the ground freezes a mulch of manure is placed over the row. In the spring when the bright weather comes the plants should be examined in order to see whether they are growing or whether the soil is soggy and cold. In either case the mulch should be removed from over the row and should be left in the center so that, in case any weather should come when the safety of the plants is at all endangered, the old mulch may easily be applied to protect them.

The seed of the standard varieties of sweet peas is cheap, and the advantage gained in obtaining early flowers, if the plants survive the winter, is worth the effort.

Spring planting.—As soon as the frost is out of the ground and the soil in workable condition in the spring, a heavy application of superphosphate of lime

> should be made and raked in. Care should be exercised not to get the soil too loose, and for this reason it is best to confine all stirring of the soil to smoothing the surface. Especially is this true with light soils, which, if stirred deeply in the spring, must be well firmed. Heavy soils that are likely to bake may be improved by working in a light dressing of old, thoroughly rotted manure. * * *
>
> One method recommended is to hollow out a broad trench, 24 to 30 inches wide and 2 inches deep, and then sow the seed 1 inch deep in single or double rows. The trench should be kept open for six weeks in order to retain the water. This system is very good in a garden where all cultivation is given by hand; but where many rows are grown and cultivation is done with a horse and cultivator, it is manifestly impossible to make or to maintain such a trench. Furthermore, when horse cultivation is to be used there would be difficulty in keeping the young plants, if planted below the surface, from being covered during the early cultivations. Therefore, planting on the level is necessary in field culture. It is advisable, however, in garden culture, to plant so that when covered the row will be 2 inches below the ordinary level.
>
> Shall the planting be in single drills, broad drills, or double rows or drills? It matters little, provided sufficient room is allowed for the growing plants.

Another method of securing early blooms out of doors, which is practiced by many English growers and is especially valuable for exhibition purposes is to sow the seed in pots under glass, after which the plants are hardened in cold frames and planted out. Pot-grown plants should be started in February or March, the time depending somewhat on the latitude and seasonal conditions.

> In order to secure suitable plants six seeds should be sown in 4-inch pots, using light, rich soil. * * *
>
> When the plants are 2 or 3 inches high they should be given supports of short twigs and placed in a cold frame. Here they should be given plenty of air at every opportunity in order to secure a short, sturdy growth. If the plants do not catch hold firmly, they may be tied with raffia. When spring begins and the soil is in good condition the pots may be planted in the open 1 foot apart in a single row or 2 feet apart in a double row. In the latter case the plants alternate.

Sweet peas should be given some support from the time they begin to make tendrils. A variety of supports may be used, but, as Dr. Beal says:

> In this country, where good, twiggy boughs can be obtained, such boughs unquestionably form the best support to use, since they are the most natural. In many places birches can be obtained in lengths of 12 to 14 feet. These may be prepared in the lengths desired. * * *
>
> If the soil has been prepared properly and the plants look strong, and if the grower sees that the plants are watered and given every care, then the support should be 6 feet high. If the soil is only moderately fertile or has not been deeply prepared, or if the grower does not intend to keep all seed pods picked off or can not water the plants in order to overcome drought, the support should be kept down to 4 feet. The variety has something to do with the height of the support, whatever the care bestowed, some varieties being naturally dwarfer growers.
>
> The sticks should be cut in late winter or very early spring, so that they are still rather green and tough enough to bear the load until the end of the sea-

son. They should be inserted in the soil at least a foot, because when clothed with vines to a height of 6 feet a strong windstorm exerts a tremendous leverage on them. Unless the sticks have been inserted deeply, or if they have become too dead and brittle, the row will go down under the force of the wind and the great weight of the wet vines. In order to guard against disaster, strong stakes are sometimes placed every 10 feet and wire is run lengthwise through the sticks and fastened to the stakes. It is desirable to have the sticks bushy at the top, so that they spread out more than at the base; if not naturally so, leaning the sticks alternately outward will produce this result. This gives greater freedom for the vines when in flower.

Netting.—When other systems of supporting are to be employed it is quite imperative to provide a support of small, short twigs as soon as the seedlings begin to produce tendrils. This method prevents the rain from beating the small plants down and enables them to get up to the other support. In city gardens, owing to the difficulty in procuring suitable sticks, wire netting makes a very satisfactory support. The peas do not cling to it so well, but it is cleaner and neater in appearance, which is a compensating advantage.

The large 4-inch mesh is preferable, but in many places this is not procurable, and the ordinary chicken netting or fence is used instead. Strong stakes at intervals not to exceed 10 feet are used to support the netting. One advantage of wire netting is that if stakes 6 feet high are used a 42 or 48 inch strip of netting may be placed in position, and if the season or soil is favorable and the peas grow above this, a narrow strip of netting may be added or a string or wire stretched from stake to stake over the row. A well-galvanized netting can be used repeatedly for several years, and will last longer if taken off in the fall and stored.

Frequent but extremely shallow cultivation should be the rule in growing sweet peas. They should not be allowed to suffer for lack of water, but watering should not be done until it is absolutely necessary, since if the soil has been deeply prepared the roots will go down after both moisture and plant food. When water is needed it should be applied thoroughly and at least two or three times a week in very dry periods. When it becomes necessary to water the plants a mulch of thoroughly rotted manure around the plants will be of great assistance in preventing too rapid evaporation.

The above-mentioned writer lays great stress on the necessity of dispodding.

In order to have fine flowers and a long succession of bloom, it is infinitely more necessary to keep the seed pods rigorously picked off than it is to cultivate, mulch, or water. The latter operations go for naught unless the pods are picked off. The writer thoroughly believes that the importance of watering has been overemphasized and that too many amateurs prefer to use the hose rather than to pick pods; then they assert that the sweet pea is not what it used to be—that it has lost constitution and the like. Of course the more highly developed the variety the less certain it is to bear up under neglect. There were on the trial grounds at this station in 1910 some of the oldest varieties, introduced from 1865 to 1890, then the latest hooded and grandifloras, and finally the waved type. Although no pods were picked from the first two types after July 20, there was a noticeable difference in the flowering habit. The old varieties were continuously blooming profusely, while the second class were sometimes completely destitute of flowers. The same holds true with regard to length of stem. Some plants of Countess Spencer were treated likewise in order to note the effect, and for them the season was over early in August.

The lesson is that if the grower does not intend to comply with the requirements of the improved types, it is better to grow Butterfly, Captain Clarke, Peach Blossom, and other small-flowered, precocious varieties.

Fertilizers.—After sweet peas are in full flower fertilizers may be applied. The best and safest fertilizer to use is liquid manure, diluted to the color of weak tea and applied once a week. It is often advantageous to alternate this with sulphate of ammonia or nitrate of soda at the rate of 1 ounce to 6 gallons of water. The plant usually responds better to phosphorus than to nitrogen, and even potash is often beneficial. Nitrate of potash and phosphate of potash dissolved at the same rate as the above-named fertilizers is of the proper strength to apply.

The most troublesome insects that attack sweet peas in the United States are the red spider and the pea aphis.[1]

The most serious fungus disease attacking the sweet peas in this country is the powdery mildew, which is often found late in the season when the plants are almost through blooming. The stems, leaves, and other parts of the plant become covered with the white, powdery coating. The disease may appear after a rain followed by very cold nights and hot days. The plants should be sprayed with potassium sulphid or dusted with sulphur or with a mixture of lime and sulphur, 2 parts of the former to 1 of the latter.

WINTER-FLOWERING SWEET PEAS.[2]

Sweet peas have been grown under glass to a limited extent for a long time, but the commercial importance of their winter culture dates back only to the development and introduction some 10 or 12 years ago of true winter-flowering sweet peas.

In a recent bulletin of the New York Cornell station, A. C. Beal traces the origin of the various groups of winter-flowering sweet peas, tells how they are grown, and describes over 70 varieties which were tested for two seasons under glass and also grown for one season out of doors.

The distinguishing characters of the winter-flowering type are described as follows:

The winter-flowering type is absolutely distinct in its habit of growth and its early flowering character. Unlike the garden types, which apparently stand still for a time when only a few inches high while side shoots are developed, the winter-flowering peas grow rapidly until they attain a height of 2 to 4 feet; then they begin to flower freely, after which time side shoots are developed. In trials at this station the varieties of the winter-flowering type, planted September 24, came into flower between Thanksgiving and Christmas; while some varieties of the waved and the older types, planted at the same time, did not flower until the last week in April. Many varieties of the first-named type were flowering freely at the holidays, but the record would have been surpassed had it not been for the fact that during the month of November the region about Ithaca had not an entire day of sunshine and had only two partly sunny days. December was almost as dark and cloudy.

---

[1] The red spider (*Tetranychus bimaculatus*), also known as the greenhouse red spider, is treated in detail in Circular 104 of the Bureau of Entomology, a copy of which may be obtained upon application. Readers interested in the pea aphis, an insect which attacks peas practically throughout the country and which is a very injurious pest, may obtain full information in Circular 43 of the Bureau of Entomology.

[2] Compiled from New York Cornell Sta. Bul. 319.

The winter-flowering peas make their greatest growth under glass. When planted in the spring in the open ground they make a very slender growth as compared with the garden type, and flower early in the season when a few inches high. However, they flower very profusely and continuously.

The garden type stools out well when planted under glass, but requires the entire winter for growth if planted in the fall. It is said by a practical grower that seed planted in January will flower as soon as that planted in August. This difference in habit of growth, manifesting itself very early, is of great value to the florist in enabling him to guard against loss from procuring the wrong seed.

The flowers of the winter-flowering type are generally of the open form of Blanche Ferry, a dwarfed garden variety introduced in 1889. They show either a direct or indirect relationship to that variety. Some of the English and American raised varieties are hooded, and one grower is perfecting a waved-flower group. As tested at the Cornell station the open-flowered type was superior in substance in midwinter, and the flowers remain open, whereas the hooded varieties are often too much hooded and do not show their real size to advantage.

Winter-flowering sweet peas grow 6 to 10 or more feet high. They need all the light they can get to promote free blooming; hence low or dark houses are not practicable. They should be grown preferably in solid beds, since the plants require a deep, moist, cool soil. Thorough drainage should be provided, and this will be assisted by raising the beds at least 1 foot above the walks.

When planning to grow sweet peas under glass in solid beds the house should be cleared as early as possible. Trench the soil 2 feet deep. If the beds have been manured annually the bottom soil may be brought to the surface. In new houses, in case the beds are to be raised a foot, trench the soil 18 to 24 inches deep if it is a good loam; if not, remove the soil and fill the beds with good soil. This gives an additional foot of loosened soil when the bed is full, but it is needed for additional drainage. In turning this original soil in a new bed apply a heavy coat of good decomposed cow manure in the trench. Then spread on top a 3-inch coat of manure and fill in with the prepared soil. In the old beds put a 3-inch layer of manure in the bottom of the trench and another about a foot below the top. The soil should remain thus until about the time for sowing; if a month or more intervenes, it is much better. At this time fork over the top layer 1 foot deep, which mixes the upper layer of manure with the surface soil.

While good crops of sweet peas may be grown on benches, yet they require more care than when in beds. The sweet pea is frequently grown as a crop to succeed chrysanthemums, particularly by those florists who do not devote a great amount of space to pot plants. In order to have flowers for Christmas the early chrysanthemums should be cleared from the house by October 20 and the space filled with good sweet-pea plants transplanted from pots.

The best results will be secured from strong-germinating, outdoor-grown seed of this type. Seed procured from exhausted greenhouse-grown plants often germinates poorly or produces weak plants. The first row should be sown at least 5 feet away from steam pipes along the side walls. East and west rows may be planted 5 feet apart; north and south rows 3 feet apart. Sow the seed in drills 1 to 1½ inches deep and about the same distance apart in the drill. The surface should be kept level.

The winter-flowering varieties may be started in pots and transplanted later on, but they give better results when started in permanent position. A day or two before planting, the beds should be thoroughly saturated with water or with a strong dose of liquid manure. The seed may be sown as soon as the surface has dried off. White-seeded varieties suffer from retarded germination or excessive moisture, hence may best be soaked in water for several hours and then lightly stratified with sand in flats until they begin to swell. The seeds may then be sown in moderately dry soil, as with the other varieties.

If the soil has been saturated before planting, no more water should be applied for perhaps a week, or only when the soil is no longer moist 3 inches below the surface. When a thorough watering is not applied first, and the seed is sown and watered in, as a rule not enough water is given to saturate the soil very deeply. The result is that the plant confines its root area to this shallow moist layer and does not root deeply. It therefore suffers from extremes, and any lack of moisture is followed by a check from which it never recovers. On the other hand, if the preparatory watering is given and water withheld until there is need of it, the roots strike downward into moist and cooler soil, where they overcome, as far as possible, the effects of the hot days. The sweet pea must be kept growing steadily from the day the seed is sown. When water is needed do not apply near the plants, but between the rows, where it should be given liberally. This treatment is especially important with the early plantings. One reason why water should not be applied too near the plants is that they are especially subject to damping off. This trouble becomes more prevalent in October and November, when there are more cloudy days, cool nights, and like conditions. Because of this no soil should be heaped around the stem.

To secure the best returns from winter-flowering sweet peas they should be blooming freely during holiday or festive seasons. The rate of growth will be influenced somewhat by the amount of daily sunshine during the fall and early winter. In the Cornell tests a good crop of Christmas blooms was secured by sowing the seed in August.

When a good crop of sweet peas is desired for Christmas, the seed should be sown the 20th of August. When sown September 1 the plants will flower in January; when sown September 15 the main crop will be in February; and when sown in October the crop will be ready in March. November sowings flower in the latter part of March; December sowings in April; January sowings in April and May; February sowings from May 1 on; and a March sowing in May or June. This gives the time when a reasonable crop can be expected, although flowers will be cut, especially with certain varieties, in a shorter interval than that given.

Some of the varieties in the tests at this station, sown October 20 and benched December 20, gave flowers during the last week in January, but not freely until about March. Some sown November 20 and benched December 20 began flowering in February and gave an abundance in March. Seed sown in beds September 24 this year gave flowers on Thanksgiving Day, although during the whole month of November there was not one clear day and there were only two partly clear days.

Winter-flowering peas grow very rapidly, hence training should commence as soon as they are up. Supports may consist of string, wire and string, or wire netting. Wire netting was preferred at Cornell, although it is condemned by commercial growers, who claim that the vines do not cling to it well and that more crooked stems occur than when the vines are trained on string.

Special effort must be made to keep the temperature down during the early growth period, for the nearer the natural outdoor spring conditions are approximated, the stronger and healthier the plants will be. Give full ventilation day and night, as late as possible, without freezing.

When the flower buds can be felt in the tips of the growing stems the temperature should be raised 1° a night until 50° is attained, which is the proper temperature during December, January, and February. From about the end of February on a night temperature of 48° is better. On bright days a rise of 10° or even 15° may be given. On cloudy days 55° is high enough, for higher temperatures promote soft, succulent growth that wilts when the sun comes out. Plenty of ventilation should be provided at every opportunity, as this, with careful regulation of temperature, causes a firm growth.

Sweet peas are subject to attack by the more common greenhouse insects and are also apt to become diseased unless proper attention is paid to soil conditions, temperature, and ventilation.

Sweet peas are especially subject to attack by the red spider, but unless the plants are too near heated pipes such attacks do not often occur except in the fall months. The careful use of water after the plants have attained a height of a few inches will eradicate this pest.

The pea aphis attacks sweet peas from the time they appear above ground. It can soon destroy the young plants, as well as weaken the plants at any stage. Treatment for this insect has already been referred to on page 9.

Climbing cutworms and snails, if present in greenhouses, will destroy sweet peas. The former insects * * * are combated by using compost that has not been covered by a rank growth of weeds and grass. When their work is noticed a search should be made for the worms under any mulch or lumps of earth on the bench, where they are coiled up during the day. They may also be picked from the plants at night while feeding. Snails can be controlled by the application of lime and soot to the surface of the bed or benches.

The damping-off fungus has already been mentioned as causing the loss of young plants. Sometimes plants are seen with white or yellow streaked foliage. From experience at this station it appears that such a condition may follow the use of any soil that is not sweet. An instance occurred when a mold growing over the ashes of a bench entered the bottom of some pots of peas, causing the soil to become stale and musty. All the plants where this occurred showed streaked foliage later. The disease is undoubtedly physiological in its nature and is thought by practical growers to occur sometimes from the use of too much or too fresh manure on young plants.

The dropping of flower buds is often a cause of complaint from growers. The first flower buds frequently do not set on vigorous, thrifty plants. Usually this condition soon disappears, but sometimes it is necessary to keep the plants a little dry and to abstain from the use of fertilizers until the plants are blooming freely. The loss of the buds will follow a sudden fall in the temperature or will result from overwatering. Another cause is growing the plants in too cool an atmosphere. Plants that are grown in the proper temperature, with careful attention to watering, ventilation, and feeding, do not fail to give an abundance of flowers.

Mildew sometimes attacks sweet peas during the autumn, unless the temperature and ventilation receive attention. It has been found at this station that mildew yields readily to applications of sulphur to the pipes, and to the use of flour of sulphur dusted on the infected leaves. As soon as the fires are started in the fall some sulphur should be applied to the pipes as a preventive. This should be used judiciously, however, for an interesting case came under observation at this station during the past winter of the danger of using sulphur too strong. An application had been made, and on a very cold night the pipe covered with the sulphur was turned on, the result being that every flower which was well advanced or open was scorched so that most of the flowers had to be thrown away. No injury to the plants occurred.

SOUTHERN BUR CLOVER.[1]

E. F. Cauthen, of the Alabama station, states that "many southern farmers have long felt the need of winter crops for pasture purposes and soil improvement. As the ability of legumes to secure nitrogen from the air becomes more generally understood, the greater is the inquiry for a winter legume that will fill these important needs. Southern bur clover, or winter bur clover, as it is sometimes called, meets these requirements remarkably well. It is easy to grow, is adapted to many kinds of soil, and to begin its growth in a small way does not require much expense."

Bur clover (fig. 1) is not a true clover, but belongs to the Medicago family,[2] being closely related to alfalfa and melilotus. The plant is a native of southern Europe and western Asia. It is a low, spreading annual that readily reseeds itself when left alone and spreads slowly over old fields and pastures. It is easily destroyed in cultivated crops and need not prove a troublesome weed to the farmer.

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[1] Compiled from Alabama College Sta. Bul. 165; Texas Sta. Bul. 108. See also U. S. Dept. Agr., Farmers' Bul. 147, p. 23.

[2] For a full discussion of the nonperennial species of this family see U. S. Dept. Agr., Bureau of Plant Industry Bul. 267.

Bur clover seems to be adapted to any territory in which cotton can be successfully raised, and it grows in all the Gulf and South Atlantic States. If the plants become well rooted before cold weather they will stand a considerable freeze, the tops, if frozen, renewing their growth upon the resumption of warm weather.

The plant will grow on almost any kind of soil, but makes its best growth on rich, well-limed, sandy loams. On poorly drained soils, which are frequently acid and cold and not favorable to the development of nitrogen-fixing bacteria, the clover is often "scattering and small and of a yellow, sickly color; but as the soil becomes better drained, sweeter, and more completely inoculated, the clover becomes thicker and makes a heavier growth."

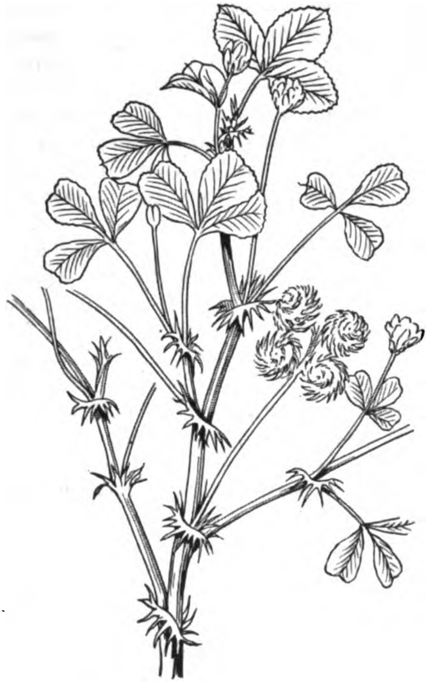

FIG. 1.—Bur clover.

Artificial inoculation is necessary for the successful growth of bur clover unless the land has grown California bur clover, melilotus, or alfalfa.

A very satisfactory way to secure this necessary inoculation is to sow the seed in burs. These are harvested by sweeping them up with a stiff broom, which brings together the dirt and litter which contain the bacteria peculiar to bur clover. When the seed and litter are sown they carry inoculation into the new soil. Hulled or recleaned seed do not carry the bacteria in a satisfactory quantity.

Soil from fields of bur clover, alfalfa, or melilotus scattered broadcast at the rate of 400 or 500 pounds per acre at the time of seeding is a very satisfactory way of introducing the bacteria, provided the cost of labor to handle and transport this soil is not too great. If this soil can be obtained close at hand and at small expense, it will doubtless pay to put it with the burs, thereby increasing the chances for better inoculation and of improved crops the first year. If the soil has to be transported a long distance and is expensive to handle, the amount per acre may be reduced to 200 or 300 pounds.

When soil is used for inoculating purposes it should be mixed with the seed and sown when the sun is not shining, as sunshine may kill the bacteria. It has also been found that a good application of well-rotted stable manure assists in the development of bacteria and of the first year's growth of clover;

southern bur clover requires two or three years for the soil to become sufficiently inoculated to assure a maximum stand and growth.

The uses of southern bur clover are many. It makes an excellent pasture for all kinds of live stock. For forage purposes it yields some hay, though the tendency of it to fall down when planted alone makes its mowing difficult. By planting it in combination with grain it is forced to grow more upright, and mowing becomes an easy operation.

Probably the greatest use of southern bur clover is that of soil improvement. In winter, when the cotton and corn fields are usually bare, a green cover crop of clover would lessen the loss of fertility by washing and leaching, and at the same time it would add to the soil a large quantity of atmospheric nitrogen.

FOR PASTURE.

Southern bur clover forms an excellent pasture in early spring and late winter for sheep, cattle, hogs, and horses. At first the animals may not like the taste of the clover, but if they are put on it while it is tender and other green feed is scarce, a relish for it may soon be acquired.

Enough animals should be kept on a clover pasture to keep it eaten down closely. Close grazing will not destroy it but will keep it tender. Even sheep, which are the closest grazers of our ordinary domestic animals, do not eat it so closely that it will not reseed itself.

The seeds germinate after the fall rains begin and, if the season is warm, light grazing will be furnished before the hard part of winter. During the warm spells of the winter and early spring the clover grows rapidly and often furnishes good pasturage. In this latitude it offers its maximum grazing in the middle of spring. As the grass comes up under the clover the stock quit the clover and take to the tender grass.

The amount of pasturage furnished per acre by southern bur clover during its growing season will compare favorably with our best native grasses.

Southern bur clover, so far as the writer knows, has never caused cattle to bloat, though it belongs to the class of plants that cause this trouble. Before they are accustomed to grazing the clover it might be well not to put them on it when they are very hungry or when the clover is wet with dew or rain.

Southern bur clover grows well on Bermuda sod. Late in the spring the grass becomes very tender, because it is shaded and fertilized by the clover. As the clover dies down the Bermuda grows rapidly. It is believed that its fertilizing effect upon the grass is equivalent to a top-dressing of barnyard manure. Another noticeable benefit of bur clover to the sod is the shading and smothering effect on early weeds that infest pastures.

There are two common methods of seeding southern bur clover on Bermuda sod. First, the burs are scattered broadcast over the sod in August or September, and the fall rains wash them into the low places and pockets, where the seeds germinate and grow; however, this method of seeding does not secure a uniform stand.

The second method is to open parallel furrows about 4 or 5 feet apart with a small scooter plow and drop or scatter the burs in these at the rate of 1 to 2 bushels per acre, depending upon the thickness of stand desired the first year. The seed is covered by dragging a brush or drag harrow across the open furrows.

This thin seeding will not furnish much grazing the first year, but it will give enough plants to grow an abundant seed for the second crop, and future seeding will take care of itself.

FOR HAY.

The spreading habit of southern bur clover and its tendency to fall down will prevent its common use as a hay crop. However, hay can be made of it if it is planted very thickly on highly fertilized soil. But the best way to make a hay crop of it is to sow it with fall grain.

Southern bur clover and oats or wheat may be planted together in September or October. Three to six bushels of burs and 2½ bushels of red rustproof oats or 1½ bushels of some early wheat should be seeded per acre. By crowding the grain and clover together the clover is forced to grow upright and a larger amount is harvested.

Cutting and curing.—The time for mowing southern bur clover for hay is when its blooms are appearing abundantly. If the cutting is not done at the proper time the plants fall down, and that portion which is next to the ground sheds its leaves, becomes woody and dark, and the market value of the hay is lowered.

If grain and clover are combined for hay they should be mowed when the grain is in the milk stage. If allowed to stand much longer the straw of the grain becomes woody and is not so palatable.

Curing of clover alone is not difficult. After the dew is off the mower may be started and run until noon. Before the dew appears in the evening the morning cutting should be raked from the swath to a windrow, where it may lie for one or two days. Then, if racks * * * are available the hay may be put on them and cured ready for baling without further handling. If the clover is allowed to remain in the swath a long time it becomes dry and brittle and loses many leaves, which form a valuable part of the hay.

A mixture of clover and grain cures rapidly in the swath, because the clover is held apart by the straw which permits the air to circulate freely through the hay. After curing two or three days in the swath it may be raked and thrown on racks to remain until it is completely cured.

Feeding value.—In two experiments at the Alabama station bur clover alone gave a yield of 3,493 pounds of hay per acre. Bur clover in a mixture of crimson clover and oats gave a yield of 5,520 pounds per acre of hay. These yields were obtained on land that in ordinary seasons produces a bale of cotton per acre. The soil was well limed and inoculated.

Chemical analysis of bur-clover hay showed water 7.59 per cent, crude fat 4.22 per cent, crude protein 19.5 per cent, crude fiber 25.7 per cent, and ash 9.89 per cent. This analysis shows that bur clover ranks very high in protein and fat. When cut at the right stage and carefully cured it yields a hay which compares well with the best cowpea-vine or clover hay.

AS A SOIL IMPROVER.

Probably the greatest value of this clover to the southern farmer is its use as a winter cover crop and a soil improver. During the winter it makes considerable growth and utilizes the soluble plant foods that might be washed or leached from the soil. Masses of fine roots penetrate and hold the soil together during the heavy winter and spring rains and prevent surface washing. In the spring the roots rapidly decay and add humus to the soil.

Southern bur clover like other legumes has the ability to gather nitrogen from the air and put it in the soil by means of nitrogen-gathering bacteria. The tubercles or nodules on the clover roots may be compared to fertilizer factories which gather [nitrogen] from the free and unlimited supply of [the atmosphere] and manufacture it into plant food. In order that the bacteria in the nodules may get an unlimited supply of nitrogen the air must circulate freely through the soil; this necessitates good drainage and thorough cultivation.

Nitrogen is the most expensive element of plant food in commercial fertilizers. By the use of bur clover and other legumes the farmer's bill for commercial fertilizer may be greatly reduced.

A crop of bur clover producing 3,490 pounds of hay leaves approximately 1,375 pounds in stubble and roots, if crimson clover may be used as a basis of calculation. From chemical analysis of bur-clover roots and stubble made at this station it was found that the roots and stubble from a crop of 3,500 pounds of hay put in the soil about 20 pounds of nitrogen. This amount of nitrogen is equal in round numbers to 133 pounds of nitrate of soda or 266 pounds of cottonseed meal.

The entire growth of clover may be plowed under in the spring as a fertilizer; or it may be cut for hay or grazed, and the remaining part of the plant turned under for soil improvement.

Southern bur clover makes its most rapid growth in April and May. There is a tendency among farmers to plow it under too late in the spring and, as a result of the late plowing, the land is often poorly prepared, crops are not planted at the proper time, and their cultivation is made difficult. A period of two to three weeks is needed for the soil to settle down, then a second plowing and harrowing should be given the land before planting a crop of cotton or corn.

The practice of sowing southern bur clover in cotton and corn fields as a catch crop offers many advantages over the leaving of fields bare through the winter. The soil may be prevented from washing and leaching, and at the same time atmospheric nitrogen and other organic matter be added. The fields may furnish late winter and early spring pastures in addition to the soil improvement.

The seed in burs is sown at the rate of 3 to 6 bushels per acre, depending upon the amount of seed available and its cost. When they are grown on the farm, the burs and trash may be raked up and scattered over the land liberally.

The best time for seeding southern bur clover in the burs is August and September. The rains wash the burs down into the middle of the rows and cover them with soil. Those falling in depressions and on damp soil will soon germinate, while those falling on high places may not germinate till the late fall rains. Those germinating late will not make much growth before spring.

A better practice is to sow the seed in the cotton and the corn middles and cover it with a heel-scrape or spring-tooth cultivator. By using short singletrees and wrapping the traces little damage is done to the cotton or corn. If the cotton is open the seeding may follow the pickers without much loss.

GROWING AND HARVESTING SEED.

The greatest problem for the farmer to solve in introducing southern bur clover on his farm is the matter of securing seed cheaply. At present very few farms are growing seed for the market. Scarcely enough seed is obtainable at the present time to supply a limited number of farms.

The scarcity of southern bur clover seed is due largely to the difficulty in harvesting it. At present no machine has been made that will do satisfactory work.

The invention of an inexpensive huller would greatly encourage the growth of more seed. Until these problems have been solved the method of seeding in burs will be followed, which is desirable where inoculation of the soil must be done at the time of seeding.

Most of the seed for sale is harvested by sweeping or scraping it together with stiff brooms after the plants have died down. This method gathers not only the seed but stems and other litter and soil and makes a bulky mass to ship. If the seed is to be used on the farm where it is grown the matter of bulk is of little consequence. It may be raked up, hauled, and scattered upon the land to be seeded. To avoid interference with weeds and grass the seed should be gathered as soon as the plants die down.

Probably the best way for the average farmer to supply himself with seed is to grow a small seed patch. A small area of fertile soil may be set aside for this purpose. It should be well prepared, highly fertilized with stable manure, well limed, and seeded at the rate of 8 to 10 bushels of burs per acre. In case of a poor growth the first year the plants should not be destroyed but allowed to mature their seed. In the early autumn another dressing of stable manure should be applied, the seed evenly scattered over the ground, and covered smoothly with an Acme or spring-tooth harrow. The second year the yield of seed will be greatly increased. Growers have reported yields of from 75 to 150 bushels of seed in burs per acre. A bushel of seeds in burs weighs 10 pounds.

RESEEDING.

Southern bur clover produces large quantities of seed. The plants die down in the spring and leave the seed on the ground where it remains through the summer. When the fall rains come the seeds in the low places germinate and begin their growth without any further preparation of soil. After the seed has matured the land may be plowed and planted to some other crop, as cotton, corn, etc. The cultivation necessary for these hoed crops will not destroy the clover seed; at the proper time the seed will come up and make a cover crop. It has been observed that it continues to come up each fall for two or three years.

Some farmers leave balks in clover sod in the spring when they prepare the land for cotton and corn and plow out the balk after the clover seed has matured. Where the rows are made wide this is a very satisfactory way to secure reseeding. A 2-foot balk will grow an abundance of seed.

The balk system must be employed with care. On hard clay lands the balk may become weedy and difficult to manage; especially is this probable if the season is extremely dry or extremely wet.

For crops like cowpeas, sorghum, peanuts, and sweet potatoes, bur clover will mature its seed in time for the land to be plowed.

IMPROVING THE TYPE OF SHEEP FOR THE SOUTHWEST.[1]

Each type of domesticated animal can thrive with the aid of man under a wide range of conditions, but the best development of any breed or type of live stock can never be obtained unless that type possesses the natural qualifications which render is specially fitted to the environment in which it is to be maintained. Thus, it is not to be expected that the breeds of sheep best suited to cold and humid climates will be best adapted to the subtropical conditions of the southwestern United States.

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[1] Compiled from Arizona Sta. Bul. 69.

Sheep raising has grown, largely through a process of natural selection and adaptation, to be a very important agricultural industry in this region. Arizona, for example, ranks thirteenth in the size of flocks, and "of the 52,362,000 sheep (1912) in the United States, valued at $181,170,000, about 1,510,000, valued at $6,493,000, are found in Arizona," but there is great opportunity for improvement both in wool production and mutton quality. The predominating blood of the native stock in Arizona is Merino, but the average clip of fine short-staple wool is only 6 pounds, and the shrinkage in scouring is stated to be about 65 per cent. A characteristic type of native sheep is the light-shearing Navajo, of which numerous flocks are found on the Navajo Reservation in Arizona and New Mexico. These furnish a long, rather coarse-staple wool, which is, however, of great value to the native weavers. Rambouillet rams were introduced into these native flocks some years ago in order to increase the wool production, but the results have been more or less disappointing, the shortening of the long staple of the sheep working much harm to the blanket industry. The introduction of the Oxfords and Shropshires to improve the mutton quality of the range sheep has proved of little value because of the high mortality of sheep of this type, both on the range and in the warm valleys, where they succumb to the sheep botfly. Moreover, the climatic conditions which exist render the rams sluggish and ineffective in begetting a high percentage of lambs.

In order to secure an improved sheep adapted to the conditions of the region the Arizona Experiment Station has been crossing natives with other types. The most successful crosses made thus far have been those obtained with Tunis sheep, which came originally from the dry climates of northern Africa. The crosses with this heat-hardy stock seem to possess special advantages over the native sheep for southern Arizona, including tolerance of hot weather, resistance to the sheep botfly, good range qualities, and excellent reproductive qualities, combined with better wool and a larger yield of mutton.

In a recent bulletin of the Arizona station, which contains an account of the sheep in Tunis and Algeria and the crosses obtained with native Arizona sheep, F. W. Wilson states that—

> In breeding a successful type of sheep for Arizona conditions it is necessary to improve (1) their breeding capacity or ability to produce a high percentage of increase; (2) their constitution or fitness for the peculiar conditions of a hot, semiarid country; (3) their herding qualities; and (4) the production of a heavy clip of good wool. Although mutton quality is generally considered secondary to wool production, it must not be overlooked where range lambs are to be produced for the early market.

He distinguishes between types adapted to the valleys and those adapted to the range.

The ideal type for the irrigated valleys should have five essential characteristics: (1) The ability to give a profitable clip of wool; (2) to produce good mutton lambs; (3) to breed with regularity at any season of the year; (4) to withstand the extreme heat of summer; and (5) to be active and alert, so as to adjust itself better to adverse conditions of climate and health. In cooler and more humid countries the modern improved mutton breeds leave little to be desired, but the native sheep of the Southwest possess better constitutions and adapt themselves more readily to adverse conditions than do the Oxfords, Shropshires, Dorsets, or Hampshires that have been under observation at the station farm. The native sheep of Arizona have been bred for wool production, and do not possess mutton conformation. They are small and do not dress out an entirely satisfactory carcass. * * *

Since the annual production of wool is expected nearly to pay the expense of keeping the flocks, leaving the lambs as profit, the ideal animal must be a heavy producer of both wool and mutton. * * *

The ideal type should thus conform more to the medium-wool mutton breeds than to the long-wool mutton breeds. * * *

The body should be well covered with a dense fleece, medium in fineness and length; face and legs should be bare, so as not to suffer from the awns of foxtail in the eyes or burs on the legs; the belly should be well covered and retain its wool permanently. The annual clip should be not less than 10 pounds.

The head should be short, well carried, and broad between the eyes; muzzle wide and prominent; face and legs black or dark in color; ears fairly long and pendent; horns absent, although scurs are not objectionable. The breast should be broad, deep, and prominent; shoulders well set, smooth, and prominent; body well filled and of good girth behind the shoulders; ribs well arched; loins well covered and of good width; across the hips level, carried well forward and smooth; hind quarters long and straight, with a good leg of mutton carried well down.

The body should be of great depth, and the bone fine; the general form, as is found in the ideal types of all beef and mutton breeds, should be rectangular or square, with legs well set; hocks should be gently sloping; pasterns and feet neat; and hind quarters larger than fore quarters. The animal should be symmetrical throughout, giving a pleasing appearance.

A vigorous constitution should be shown by a large heart girth and by depth and width of the fore quarters, as well as by carriage and activity.

Since the sheep botfly abounds in the warm irrigated valleys, the ideal type should be quick and alert in keeping it at a distance by stamping in the dust. They should, however, be neither so wild nor so timid as to interfere with putting on flesh.

The ideal ewe for valley conditions should be ready to breed as soon as the lambs are weaned late in the spring, so that yeaning will take place in the fall or early in the winter. The lambs should mature early, so as to be ready for the early market.

The ideal type of sheep for the range should possess four essential characteristics: (1) The ability to give a profitable clip of wool; (2) to produce good mutton lambs; (3) to herd together well in large numbers; and (4) to possess a good constitution. The wool-producing character should predominate to even a greater extent than with the valley type. They should clip from 12 to 14 pounds annually. Although mutton is a secondary consideration, they should be large and mature fairly early, so as to produce early lambs and a good dressed carcass. Since on the range herding in large bands and frequent migration from one range to another are necessary, herding qualities are essential in the ideal type. They should also possess a constitution suiting them to the hardships of the range, especially intense heat and continued drought.

The description of the ideal type of range sheep would be as follows: The head should be medium in size and short; eyes large and clear; ears medium in size and covered with hair. The face should be covered with short, fine hair; nostrils wide; and muzzle smooth and white. The neck should be short, thick, and well rounded into the shoulders; shoulders smooth and wide at the top. The top and bottom lines should be parallel; depth over heart marked; loins thick and wide; pelvic arch smooth and not elevated.

The fore quarters and hind quarters should be uniform in size and smoothness; chest wide and deep; ribs well sprung; flanks full and carried down well; hips large and wide, rounded rather than sloping. The legs should be well placed, smooth and wide apart, and medium in length.

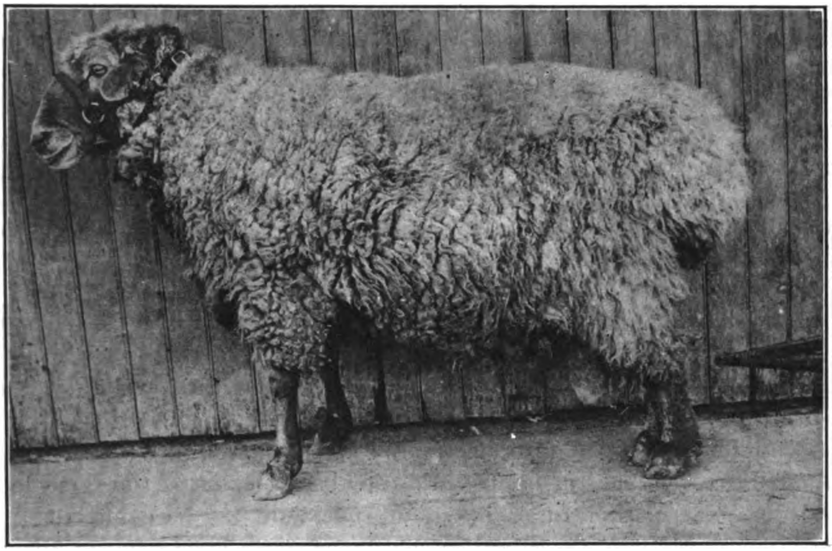

FIG. 2.—American-Tunis ram used in Arizona Station sheep-breeding experiments.

The fleece should be long, dense, elastic, and strong. When opened it should show a bright, oily luster. The wool should cover the body entirely, excepting the face and lower part of the legs.

The characteristics of the types used in the Tunis-native crosses at the Arizona station were, in brief, as follows:

American Tunis.—Desirable characters: Hardy, breed at any season, herd well, early maturing, active, and long wool. Undesirable characters: Small size, and coarse-staple wool.

Native.—Desirable characters: Hardy, herd well, active, and fine-staple wool. Undesirable characters: Do not breed at all seasons, not early maturing, small size, and short wool.

The crossing of Tunis rams (fig. 2) on native ewes has resulted in a type of sheep which in many respects shows marked improvement over both the component breeds. As this experiment develops along the lines laid down under the general plan of breeding further improvements are expected to become apparent, as has been indicated by the first crop of second-generation lambs yeaned late in the spring of 1911, into which Shropshire blood has been introduced.

The first-generation Tunis-native lambs are vigorous, active, and early maturing. Their vigor is indicated by the very low mortality at yeaning time and by their general good health and ability to withstand adverse conditions of climate and surroundings. Their activity enables them to feed over considerable areas of scant pasture and to protect themselves against the sheep botfly, and their early maturing qualities have made them especially valuable for the production of early lambs.

The general conformation of the cross is on the order of the Tunis, with improved quality of wool. The large tail of the Tunis is greatly reduced in the first generation, and, by close docking, the fat that otherwise would have formed in the heavy tail is placed more advantageously on other portions of the carcass. Of nearly 200 Tunis-native lambs only 2 have been of the same type as the dam. The first generation shows uniformly in conformation, in characteristics of the fleece, and in weight.

The fleece of the first-generation Tunis-native has a staple longer than that of the native dam and somewhat shorter than that of the Tunis ewe, but is still rather coarse and mixed with a few long hairs. It is, however, an improvement over that of both Tunis and native as regards quantity, and over the Tunis as regards quality. While the yolkiness of the fleece is greater than was expected, this may be attributed to abundance of feed and to the peculiar climatic conditions of the warm irrigated valleys.

The superior mutton qualities of the Tunis-native over the native is also easily apparent. The lambs have been uniform in conformation and size, they mature earlier than either the native or the Shropshire-native, dress to advantage, and furnish mutton of excellent quality. The rams were alert and active on the range and begot a much greater yield of lambs than the Oxford rams of the same lot.

It is evident, therefore, that "improvement has been effected in both wool production and mutton conformation. The breeding qualities and constitution have been improved, the production of early lambs assured, and the excellent herding qualities of the native types have not been lessened."

The work is an illustration of the value of selecting as foundation breeding stock for any region types which are already accustomed to the soil, climatic, and other conditions which exist in the new environment.

COMBATING FLIES.[1]

With the widespread realization of the fact that flies spread diseases as well as cause almost intolerable annoyance, there has developed a demand for efficient means of abating or controlling the nuisance.

---

[1] Compiled from Rpt. State Ent. Minn., 14 (1911–12), p. 62; Minn. State Ent. Circ. 24, 1912; Jour. Econ. Ent., 4 (1911), No. 5, p. 418; 5 (1912), No. 5, p. 400; 6 (1913), No. 1, p. 110; Trop. Agr. and Mag. Ceylon Agr. Soc., 38 (1912), No. 4, p. 332; Queensland Agr. Jour., 29 (1912), No. 2, p. 191. Consult also U. S. Dept. Agr., Farmers' Bul. 459.

The use of formaldehyde (or formalin) seems to offer one such means. R. I. Smith, of the North Carolina station, found that 1 ounce (2 tablespoonfuls) of formalin (40 per cent formaldehyde) in 16 ounces (1 pint) of a mixture of equal parts of milk and water in shallow dishes with a piece of bread in the center for the flies to light on, proves very attractive and destructive to the flies, especially when placed on the front and back porches of houses. It is less effective when used inside the house, although the method was used with good results in ridding dairies of flies.

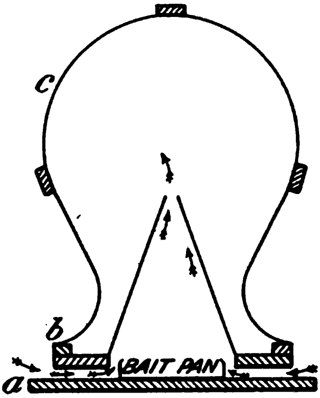

FIG. 3.—Cross section of the Minnesota fly trap.

E. E. Green, of Celon, has used the following method with success: Fill a soup plate with damp sand, cover with a disk of blotting paper, spread sugar on the blotting paper, and sprinkle it with a mixture of 1 part of formalin (40 per cent formaldehyde) with 20 parts of water.

Various forms of fly traps have been used with good results. F. L. Washburn, of the Minnesota station, describes an efficient and easily constructed form of trap (fig. 3), as follows:

> The trap is 24 inches long, 12 inches high, and 8 inches wide. The upper part (*c*), which may be oval or rectangular as preferred, serves as a receptacle which the flies enter through the opening in the top of the middle portion (*b*) made of ordinary mosquito wire screen and shaped like the roof of a house. Under this is the base board (*a*), upon which rest two tin bait pans. The space between the base board and the middle portion is about one-half inch, and between this and the bait pans through which flies enter pans, about one-fourth of an inch. Stale meat, bread, and milk are used as bait. The trapped flies are killed by immersing in hot water.

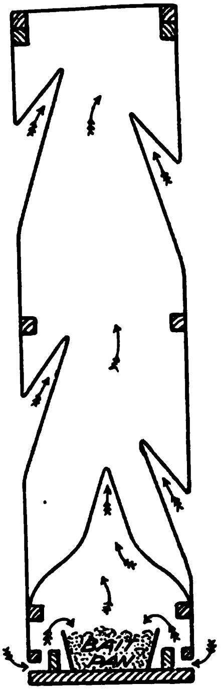

FIG. 4.—Cross section of a large fly trap for use in windows.

The essential details of a successful fly trap devised by C. F. Hodge especially for use in windows of dairies, stables, markets, etc., are shown in figure 4. This shows that—

> At the bottom is a crack, about a quarter of an inch wide, running the length of both sides. This crack admits the flies to a space covered by a ridge or roof of screen wire with holes large enough for flies to go through (punched with an

ice pick) every 2 inches. Large pans of fly bait—fish heads, poultry cleanings, brewers' waste, blood, or anything available which is found on the premises to attract flies can be set on the bottom board and thus establish a whirlwind focus for all the flies about the place. The other essential in the construction is the fold or folds in the screen walls. These are simply folds or open pleats running horizontally across the trap, pointing upward and inward. The flies, in trying to get in or out of the window, collect in these folds, run back and forth in them until they pop through one of the holes which occur every 2 inches, and they have never been seen to find a hole on the convex inside surface of the wrinkle and crawl down and out again.

This trap is built in a frame which fits closely in a window, preferably on the best lighted side of the building.

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Issued April 25, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 533.

GOOD SEED POTATOES AND HOW TO PRODUCE THEM.

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BY

WILLIAM STUART,
Horticulturist, Office of Horticultural Investigations and Arlington Experimental Farm, Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., March 13, 1913.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmer's Bulletin a manuscript entitled "Good Seed Potatoes and How to Produce Them," prepared by Prof. William Stuart, Horticulturist, of the Office of Horticultural Investigations and Arlington Experimental Farm.

This is a timely publication, setting forth a method of securing improved potato seed, which is very greatly needed in this country.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. D. F. Houston,
Secretary of Agriculture.

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GOOD SEED POTATOES AND HOW TO PRODUCE THEM.

INTRODUCTION.

A study of the statistical data upon potato-crop production in the United States for the last 45 years[1] reveals the interesting fact that during the first 5-year period, 1868–1872, the average per acre yield in bushels was practically the same as that of the last 5-year period, 1908–1912, the yield for the earlier period being 94.8 as against 96.1 bushels for the latter cycle. The intervening 5-year periods show a fairly uniform decline in each direction, reaching its lowest level between 1888 and 1892. This period happens to be the intermediate one of the 5-year cycles studied. We are practically at the same point in acre production as were our forefathers. Our increased production has therefore been due to larger acreage rather than to higher yields.

Table I shows and the accompanying diagrams (figs. 1 to 4) also show in a graphic way the average acre yields, the farm price per bushel, the acreage grown, the total production of potatoes, and also the population of the United States during the nine 5-year cycles studied. In the construction of these diagrams it has not been feasible to employ the same scale in any two of them owing to the great difference in the magnitude of the figures treated. A careful study of the first diagram (fig. 1), in which the acreage yield and farm price per bushel are given, shows that the acreage-production curve, if drawn on the chart, would somewhat resemble the curve of a scimitar blade, in which the extreme ends of the blade represent the maximum yields for each half of the curve.

TABLE I.—*Averages of acreage production, bushels per acre, and farm price for potatoes, in 5-year periods, 1868 to 1912.*

Five-year period.	Number of acres.	Bushels produced.	Bushels per acre.	Farm price per bushel.
				Cents.
1868–1872	1,246,200	117,745,800	94.8	54.9
1873–1877	1,529,800	134,773,200	88.0	53.3
1878–1882	1,934,200	150,706,200	78.4	59.5
1883–1887	2,284,000	175,197,800	76.9	48.3
1888–1892	2,619,200	193,325,000	73.7	50.7
1893–1897	2,720,000	213,461,800	77.8	44.6
1898–1902	2,716,000	220,849,400	81.2	49.5
1903–1907	3,014,200	289,399,800	95.9	56.3
1908–1912	3,566,400	343,587,600	96.1	62.3

The gradual decline in yields during the first half of this period is thought to be largely due to the following factors:

(1) The ravages occasioned by the Colorado potato beetle during the early period of its invasion of the eastern United States.

---

[1] Yearbook, U. S. Department of Agriculture, for 1911, p. 568.

(2) The financial depressions of 1877 and 1893, which brought about a well-marked decline in agriculture in New England, New York, and the other heavy potato-producing areas of the northeastern United States.

(3) A gradual depletion of soil fertility.

Of the factors which have checked the downward tendency and contributed most largely toward a return to the old production level the following are thought to have been most potent:

(1) The influence of the agricultural experiment stations, agricultural colleges, and the United States Department of Agriculture through experimentation, demonstration, and dissemination of literature.

(2) The influence of the Bordeaux-mixture treatment in the control of fungous diseases affecting the potato.

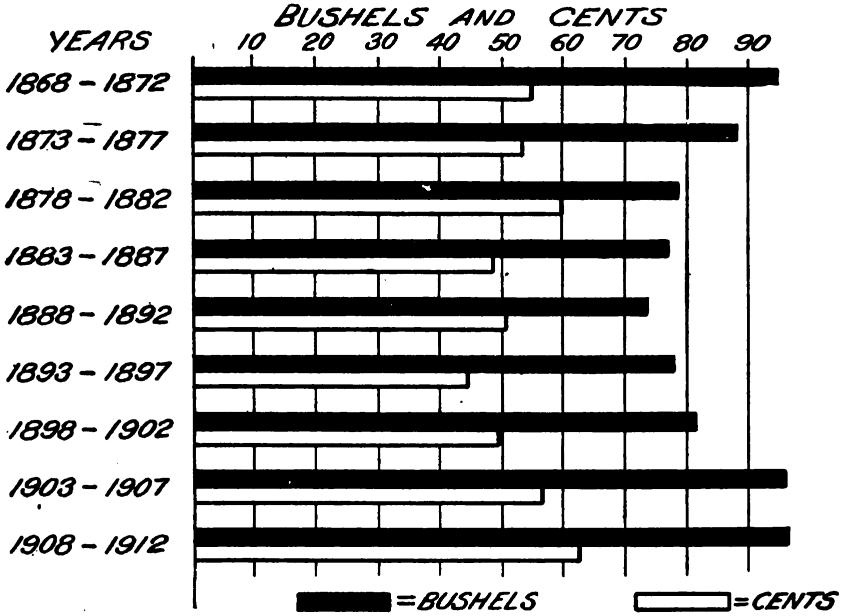

FIG. 1.—Diagram showing the average number of bushels per acre and the average farm price per bushel of potatoes grown in the United States, by 5-year periods, 1868 to 1912.

(3) The development of special potato-growing sections, as, for example, Aroostook County, Me., the Atlantic Coastal Plain trucking region, the Greeley and Carbondale districts of Colorado, and many other areas, in which the average yield is approximately from two to three times the general average for the United States.

Figures 1 to 4 show a comparison of the relation of increased production to a constantly increasing population. The diagrams show that under normal conditions production is keeping pace with population. Crop shortages are, therefore, the result of abnormal or unfavorable conditions.

In comparing the average crop production of potatoes in the United States with that of Germany and Great Britain, one can not but be impressed with the fact that, generally speaking, we have much yet to learn before we can raise our average to that of these two countries. During the years 1901 to 1910, inclusive, the average acre yield of both Germany and Great Britain was approximately 200 bushels, while that of the United States was not quite 93 bushels.

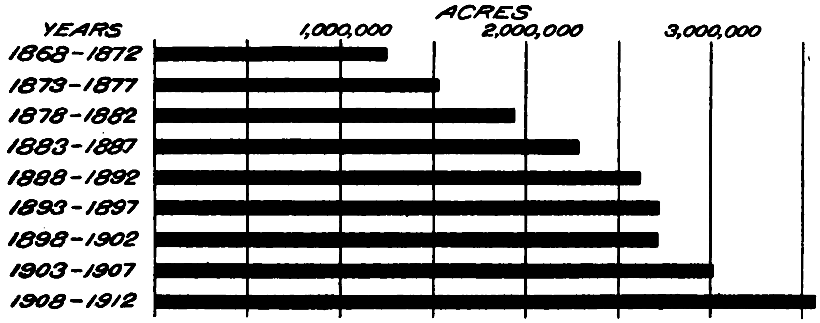

FIG. 2.—Diagram showing the average potato acreage of the United States, by 5-year periods, 1868 to 1912.

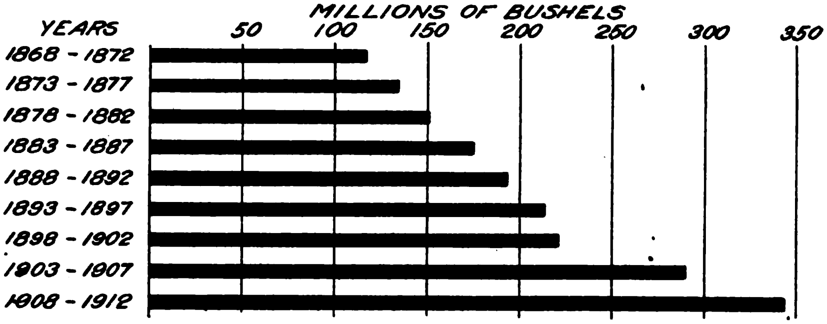

FIG. 3.—Diagram showing the average potato production of the United States, by 5-year periods, 1868 to 1912.

Of the many causes which operate to produce a low average potato yield in this country, poor seed is thought to be an important one. The American potato grower pays too little attention to his seed potatoes. The European growers, especially those of Great Britain and Germany, pay very strict attention to the quality and quantity of seed they use. This has led to the differentiation of the potato industry into seed and crop specialists. The seed specialist makes a

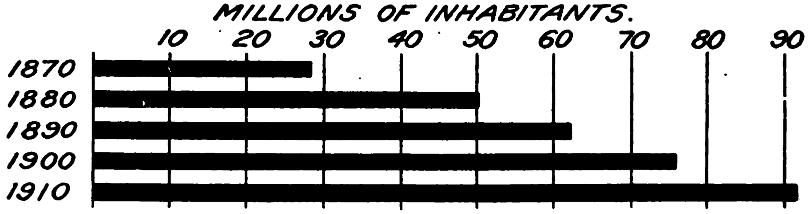

FIG. 4.—Diagram showing the population of the United States, by decades, 1870 to 1910.

business of producing high-quality seed, while the crop specialist produces a high-grade table potato. No such differentiation, at least to the same extent, occurs in this country. It is true that in certain sections we now have a well-developed seed-potato-growing industry, but comparatively few growers in these sections are paying sufficient attention to the elimination of diseased and unproductive strains or to keeping the variety grown free from mixture with other varieties. It is believed, however, that the time is ripe for demanding a better grade of seed potatoes than is now generally obtainable from either seedsmen or growers.

WHAT CONSTITUTES GOOD SEED?

The question of what constitutes good seed is a vital one, and possibly no two persons would fully agree in every particular upon this point. It would seem, however, that the following factors play an important rôle: Pure seed from productive plants, not overripe, uniform in size and shape, firm and sound, with first sprouts just showing at planting time. Seed of such quality if furnished suitable cultural conditions will seldom fail to produce a remunerative crop. A conservative estimate of the increase that might be expected from the use of high-grade seed is certainly not less than 10 per cent. Such an increase based on the average of the past five years would amount to over thirty-four and one-fourth million bushels, having an approximate valuation of $21,000,000.

PURE SEED.

The importance of securing pure seed of a given variety is best appreciated by the southern truck grower, who at the present time is practically dependent on northern-grown seed potatoes for his early crop. It frequently happens that Irish Cobbler seed potatoes as obtained from Maine have anywhere from 5 to 10 per cent, or even more, of mixture. Generally this mixture is of a much later maturing variety. The trucker plants this seed very early, much of the planting in the Norfolk trucking region being done in the latter half of February. At this season of the year there is little warmth in the soil; hence, the later maturing varieties are slower in starting into growth than is the earlier maturing Irish Cobbler. The result is an uneven germination and few, if any, tubers of the later varieties have set when those of the Irish Cobbler are ready for the early market. The grower aims to harvest as soon as most of the tubers have reached a merchantable size. It requires little imagination to see that the grower is a direct loser in proportion to the amount of mixture in the seed planted. If his yield is 60 to 90 barrels per acre, with a 5 per cent mixture he has sustained a loss of from 3 to 4½ barrels, or 6 to 9 barrels if a 10 per cent mixture was present. Usually the price of early potatoes ranges from $3 to $5 per barrel, the highest price being obtained for the first lots harvested. Assuming that the first half of his crop is marketed at an average price of $4 a barrel, allowing 40 per cent of the gross receipts for production, package, transportation, and commission charges, the grower has sustained a net money loss of $7.20 to $21.60 per acre. The loss, while relatively smaller on the remainder of the crop, is by no means insignificant.

SEED FROM PRODUCTIVE PLANTS.

Comparatively little attention has as yet been given to the subject of the productiveness or unproductiveness of certain strains of plants within a variety. It is believed that this is a very important factor in the production of large yields, as in any variety, if studied closely, many unproductive plants may be found. This assumption is amply substantiated in the results secured from investigations undertaken by the Office of Horticultural Investigations and Arlington Experimental Farm during the seasons of 1911 and 1912. During the season of 1911 certain selections were made from strong and weak plants which were being grown on the tuber-unit basis. A record was made of the number and weight of the large and small tubers in each selection, and from these five of the best were selected for planting in 1912. The results obtained in 1912 fully corroborate those of 1911, and the accompanying data give the average yields from the strong and weak plants of the 12 varieties studied:

Strong tuber units=3.28 pounds of primes; 1.18 pounds of culls. Total, 4.46 pounds.

Weak tuber units=0.20 pound of primes; 0.51 pound of culls. Total, 0.71 pound.

The strong plants gave over sixteen times as large a yield of primes or merchantable tubers and only a little over twice as many culls as did the weak plants. The proportion of small tubers would, without doubt, have been materially reduced if the vitality of the low-yielding plants had not been so weakened that in many instances no tubers were produced. These weakened plants were in many cases affected by the disease described by W. A. Orton[1] as the "curly dwarf." This is a hereditary physiological disease which, as shown by these experiments, can be eliminated by the method of tuber-unit selection.

The data also showed another interesting fact, the importance of which is brought out in the discussion of another phase of the question of good seed, and this was with respect to the average weight of the primes and culls. It was found that the average weight of the large tubers from the strong plants was 5.3 ounces as against 3.8

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[1] Orton, W. A. Proceedings, American Phytopathic Society, Feb., 1913.

ounces from the weak ones, while in the case of the small tubers the weights were 1.7 and 1.1 ounces, respectively.

The set of photographs shown in figure 5 represent strong and weak tuber units of the Gold Coin variety of potatoes. Nos. 1 and 2 show the units as they appeared in the field in 1911. Nos. 3 and 4 show the tubers produced by each of these units, and Nos. 5 and 6 show the yield in 1912 from five tuber units of the 1911 crop. Nos. 1, 3, and 5 represent the strong plants, and Nos. 2, 4, and 6 the weak plants. The average yield from these plants for 1911 and 1912 was as follows:

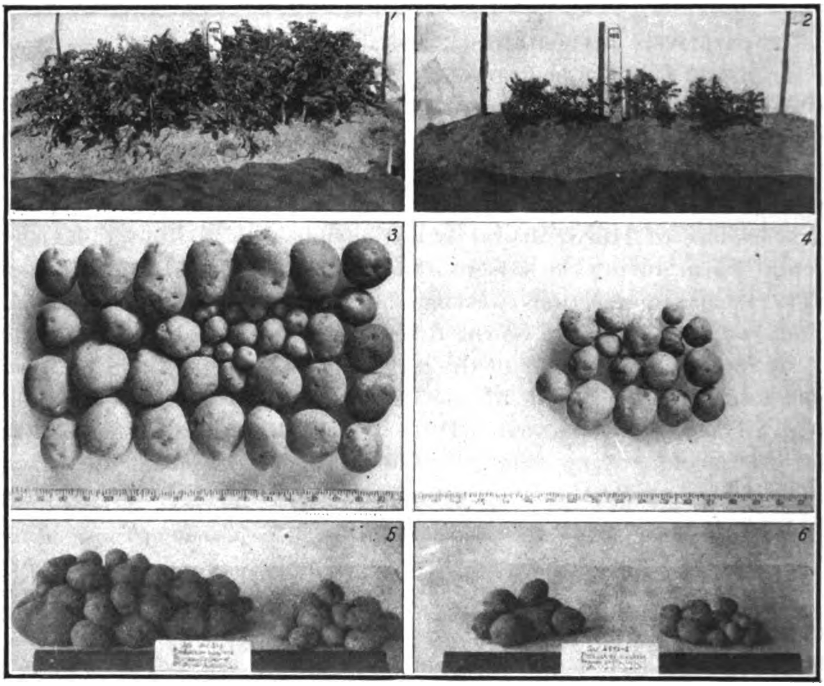

FIG. 5.—Strong and weak tuber units of the Gold Coin variety of potatoes: Nos. 1 and 2 represent strong and weak tuber units in 1911; Nos. 3 and 4 represent yields from tuber units Nos. 1 and 2; Nos. 5 and 6 represent yields in 1912 from five tuber units of Nos. 3 and 4.

Strong plants=3.2 pounds of primes; 1.77 pounds of culls. Total, 4.97 pounds.

Weak plants=0.2 pound of primes; 0.68 pound of culls. Total, 0.88 pound.

The two groups of tubers in Nos. 5 and 6, figure 5, represent the primes and culls. All tubers weighing 3 ounces or more were classed as primes, while all under this weight were considered culls.

The accompanying diagram (fig. 6) presents the differences in yield in a striking manner.

In considering the results of this investigation it should be borne in mind that a comparison of two extremes simply serves to illustrate in a more forcible manner the desirability of securing seed from vigorous, healthy, and productive plants.

The investigations of Waid[1] at the Ohio Agricultural Experiment Station clearly demonstrate the superiority of selected over unselected seed. Waid compared seed from productive plants with that from unselected stock and from low-yielding plants. The average yield of 100 hills during the seasons of 1904, 1905, and 1906 was as follows:

High-yielding seed	138 pounds.
Unselected seed	110 pounds.
Low-yielding seed	73 pounds.

The gain in favor of the high-yielding plants over the unselected and low-yielding plants was 25.4 and 89 per cent. respectively.

While the results secured by Waid are doubtless higher than might be expected under average conditions, they serve to emphasize the value of seed selection. Some interesting data have recently been published by Burritt[2] upon the methods pursued in seed selection and also of the yields secured by T. E. Martin, of West Rush, N. Y. Mr. Martin maintains a seed-selection plat from which all weak or imperfect plants are rigidly removed. At harvesting time the crop from the selection plat is sorted into two grades, "specials" and "selects." The specials must weigh not less than 12 ounces each, must have well-developed seed and stem ends, and, furthermore, must be true representatives of the variety grown, which is exclusively the Sir Walter Raleigh. The selects include all that do not pass as specials but that are of good size and shape, all unshapely or undersized tubers being discarded. The specials are used to plant the seed plat the ensuing season and the selects to plant the general field crop.

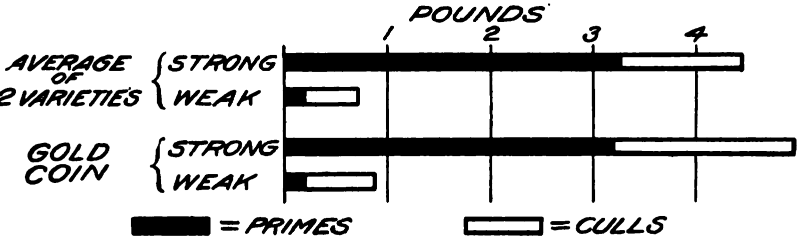

FIG. 6.—Diagram showing the average yields from strong and weak tuber units, 1911 and 1912.

The value of the method is well attested by the crops produced. The average production on an 18-acre basis for the past nine years, 1901 to 1909, has been 282 bushels per acre. The highest seasonal yield during this period was 417 bushels, and the lowest 233 bushels.

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[1] Waid, C. W. Ohio Agricultural Experiment Station, Bulletin 174.

[2] Burritt, M. C. Farmers' Bulletin 454, pp. 16–22.

These yields are being secured in a locality where the general average is approximately 150 bushels per acre.

IMMATURE SEED.

The superiority of immature over mature tubers for seed purposes is not as yet recognized by the American potato grower. The European growers, on the other hand, have long realized that, other things being equal, larger crops can be produced from immature seed than from mature seed. The results of some experiments conducted on the trial grounds of Sutton & Sons, Reading, England,[1] support this assumption.

The average production of eight varieties grown from 12 sets of immature and mature seed was as follows:

Immature seed=212 pounds of table stock; 49 pounds of seed; 9½ pounds of culls. Total, 270.5 pounds.

Mature seed=105 pounds of table stock; 39 pounds of seed; 12½ pounds of culls. Total, 156.5 pounds.

Expressed in percentage there was a gain in favor of immature seed of more than 100 per cent for table stock and a total gain of over 72 per cent.

While, as has been stated, little attention has been given to the use of immature seed as such by the American grower, yet in an unconscious way immature seed is being used to a very large extent, especially by the southern truck grower when he uses northern-grown seed for his early crop. This seed, especially that obtained from northern Maine, is in a more or less immature condition when harvested. Whether or not a still more immature condition would give better results remains to be determined.

UNIFORMITY IN SIZE AND SHAPE OF TUBERS.

Under normal conditions of growth a large proportion of the present-day commercial varieties are very variable in size and shape of tuber. To some extent both size and shape are determined by the character of the soil, rate of planting, fertilization, and cultural care given the growing crop. Outside of these modifying factors, inheritance plays a very important part. It has been recently demonstrated that most varieties contain within themselves distinct varietal strains which when isolated behave in a much more uniform manner with respect to size and shape than the composite strains of which the variety is constituted. All things being equal, the variety or varietal strain that produces a maximum number of fair-sized shapely tubers and a minimum number of ill-shaped and small tubers should prove the most valuable, because it involves less waste to both the grower and the consumer. It is particularly important at present that such strains be developed, because there is an increasing demand for fancy table stock to satisfy the requirements of a large and discriminating class of consumers who are insisting on greater uniformity in size and shape and are willing to pay a premium on such grades.

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[1] Sutton & Sons. Potato Demonstration, p. 22, 1906.

DEVELOPMENT OF HIGH-GRADE SEED POTATOES.

By far the simplest and most promising means of developing high-grade seed potatoes is that of the tuber-unit and hill-selection methods outlined below.

TUBER-UNIT METHOD.[1]

The tuber-unit method, as now generally understood, consists in selecting from the seed bin before planting time a considerable number of the most perfectly shaped tubers of from 6 to 8 ounces in weight. When planted, these tubers are quartered, as dropped, into four as nearly equal parts as possible. This is done by splitting the bud-eye cluster in each direction from seed to stem end of the tuber. In other words, the tuber is cut through its longitudinal axis. The four pieces of each tuber are dropped consecutively in the row at a distance of from 10 to 12 inches apart in the furrow. All tubers showing discoloration of the flesh or other evidence of disease should be rejected. By allowing an additional spacing between each set of fours, the four plants from each tuber are definitely isolated from adjoining ones and the grower can readily observe any variation in vigor and uniformity between the various units planted. This method also enables him to detect any mixtures that may occur in the variety. All mixtures should at once be removed. By marking those which appear to be most uniform in size, vigor, and type when the plants are still in vigorous growth, the first step in selection has been accomplished. At digging time the product of each unit is separately harvested and a further selection made from the marked units of all those which most nearly approach the size, shape, and smoothness desired. These selected tubers should be numbered with both field and unit numbers and separately placed in small sacks, preferably cotton or burlap, and stored to await further examination. The final examination should consist of notes on the number and weight of merchantable and unmerchantable tubers and their general conformity in size, shape, and smoothness to the type desired. From each of the units retained 10 of the best tubers should be selected for the next season's planting.

It is desirable to maintain the study of each selection on the tuber-unit basis the following season, because it permits a more accurate comparison of the behavior of each. The 10 selected tubers from each original unit will give 40 plants for study the second year. All selections which do not produce a reasonably uniform lot of plants should be marked for rejection. At harvest time the progeny of each selection should be kept by itself and the same data recorded as that taken on the crop grown from the original tuber unit. Only the product from such 40 hill rows as meet the most rigid requirements should be retained. The further conduct of the work will consist in the multiplication of the selected strains for field planting and the elimination of weak plants.

---

[1] For further information concerning the arrangement of a tuber-unit selection plat and a handy system of note taking, see reprint of article in Bureau of Plant Industry Circular No. 113, entitled "The 'tuber-unit' method of seed-potato improvement."

HILL-SELECTION METHOD.

The hill-selection method consists in marking the most promising plants during the growing season. At harvesting time save only those which give greatest promise. Keep the progeny of each hill separate and take the same data as outlined for the tuber unit. Plant on the tuber-unit basis the following season. For the sake of uniformity a definite number of tubers—5 or more—should be planted from each hill selection. From this point on, follow the methods given in tuber-unit work.

REQUIREMENTS FOR SUCCESS.

The only requirements for the successful practice of these two methods of seed selection are a reasonable degree of painstaking effort on the part of the grower, some 12-inch garden labels, a small pair of balances, a sufficient number of suitable small sacks, and a safe place in which to store the selected tubers until required for the next season's planting. In addition to this, the grower should have a breeding plat in which each season's selections can be developed up to the point of field-planting stock.

The selection or breeding plat need not necessarily be divorced from the general field plat. In most cases it can be more conveniently handled if it is a part of the regular field. All that is required is to set aside as many rows as may be required to plant the selected tubers. These should be preferably on one side of the field, so that they can be more readily observed. The planting furrows may be opened and the fertilizer distributed with the potato planter by removing the disks and setting the plow a trifle deeper. If a plow is used in covering, care should be exercised to avoid displacing the seed pieces.

LARGE COMPARED WITH SMALL SEED TUBERS.

In seasons of short production and consequent high prices for table stock, the question is frequently raised as to the advisability of using the small unsalable tubers for seed purposes. The answer to this question is found in a study of the data secured from the strong and weak plants. A comparison of the merchantable and unmerchantable tubers produced shows that the strong plants produced over 16 times as great a weight of large tubers as the weak plants, but only a little more than twice as great a weight of small tubers. It was found also that the average weight of the large tubers from the strong plants in 1912 was 5.3 ounces, as against 3.8 ounces from the weak ones. The small tubers, or culls, from the strong plants averaged 1.7 ounces, as against 1.1 ounces from the weak ones. From these data it is not difficult to see that in the use of small tubers one would inevitably and unwittingly select a large proportion of his seed from the unproductive and weak plants and a relatively small proportion from the productive and vigorous ones. In this connection Ballou[1] makes the following statements regarding the use of large and small tubers for seed purposes:

> The use of large tubers gives—
>
> (*a*) A very heavy, perhaps almost total, percentage of the high-producing strains.
>
> (*b*) A heavy percentage of the average or moderate-yielding strains.
>
> (*c*) A very small percentage of the inferior or low-producing strains.
>
> The use of small potatoes gives—
>
> (*a*) A very insignificant percentage of the superior or high-yielding strains.
>
> (*b*) A small percentage of the average or moderate-yielding strains.
>
> (*c*) A very heavy, almost total percentage of the low-yielding or inferior strains.

The use of small seed potatoes is only permissible when they are known to have been produced by strong, healthy, and productive plants. It is never advisable to use small tubers from the general mass produced from unselected stock.

WHOLE COMPARED WITH CUT SEED.

The subject of whole versus cut seed is one to which considerable attention has been paid at various times by the State agricultural experiment stations. The data which have been accumulated as a result of these investigations are for the most part conflicting in so far as they pertain to the use of whole seed. In general, the data given show that within reasonable limits the larger the seed piece planted the larger is the resultant crop produced. English and Scotch potato growers almost without exception plant whole tubers. The seed used usually runs from 1¼ to 2¼ inches in diameter, being screened out of a crop which as a rule has been grown especially for seed purposes. They are harvested before they are mature, and but a relatively small proportion of the crop exceeds the size mentioned. These growers believe that an earlier and more vigorous growth is secured from immature tubers.

Some of the reasons why European growers have adopted whole seed and are succeeding in producing profitable crops are as follows: (1) They are assured of an almost perfect stand; (2) there is greater freedom from disease; (3) the almost universal practice of germinating their seed before planting insures a minimum number of sprouts; and (4) the greater fertility of their land makes large yields of medium-sized tubers possible.

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[1] Ballou, F. H. Ohio Agricultural Experiment Station, Bulletin 218, p. 587.

Some of the reasons for failure in the use of whole seed in this country follow: (1) The use of small tubers from unselected stock and (2) the development of too many sprouts, with a consequent large set of tubers, which, owing to lack of thorough preparation of the soil, scant plant food, and moisture, do not reach a marketable size, at least in sufficient numbers to produce a profitable crop. The development of too many sprouts comes about through planting tubers in a dormant condition, which under favorable soil temperature and moisture starts almost every bud into growth.

Scotch and Irish potato growers plant not less than 37 bushels of seed per acre, and frequently this quantity is greatly exceeded. The American grower, on the other hand, plants from 9 to 16 bushels per acre, with an average of from 11 to 12 bushels. It is believed that the average potato production of the United States would be very materially increased if a larger quantity of seed were used.

INFLUENCE OF POTATO STORAGE ON THE QUALITY OF THE SEED.

The storage conditions necessary to insure vigorous seed at planting time are more easily provided in the North than in the South. In the former region a well-constructed cellar, pit, or cave serves reasonably well. The main thing is to keep the room temperature sufficiently low to retard germination. The ideal seed tuber is one which has not wasted any of its stored-up energy by excessive loss through sprouting. (See fig. 7.) It should be firm, with the first sprouts just showing. Such tubers can be depended upon, if suitable conditions prevail, to start quickly when planted and to make a vigorous growth.

The general practice of securing seed from the North by southern growers involves in the absence of suitable storage conditions one of two things: Either getting the seed potatoes late in the fall and holding them over in dugouts, pits, or cellars, with consequent sprouting before planting, or the risk of having the seed chilled, frozen, or overheated while in transit in midwinter. (See fig. 8.) In the writer's opinion the greatest need of the large southern truck grower at present is that of providing suitable storage facilities for handling fall shipments of seed potatoes. As a purely economic proposition the proposed change ought to commend itself. In probably nine cases out of ten the difference in first cost of these potatoes as between fall and midwinter shipments would more than offset the extra cost of storage, while the added security from danger of chilling or freezing the shipment would still further compensate the grower.

TREATMENT OF SEED FOR SCAB.

It is desirable that all seed should be treated for scab prior to planting. The formalin treatment is one of the most effective agencies now employed for scab disinfection. The seed tubers should be immersed for two hours in a solution containing 1 pint of formalin to 30 gallons of water. On removal from the liquid they may be cut and planted at once, or they may be spread out to dry and stored

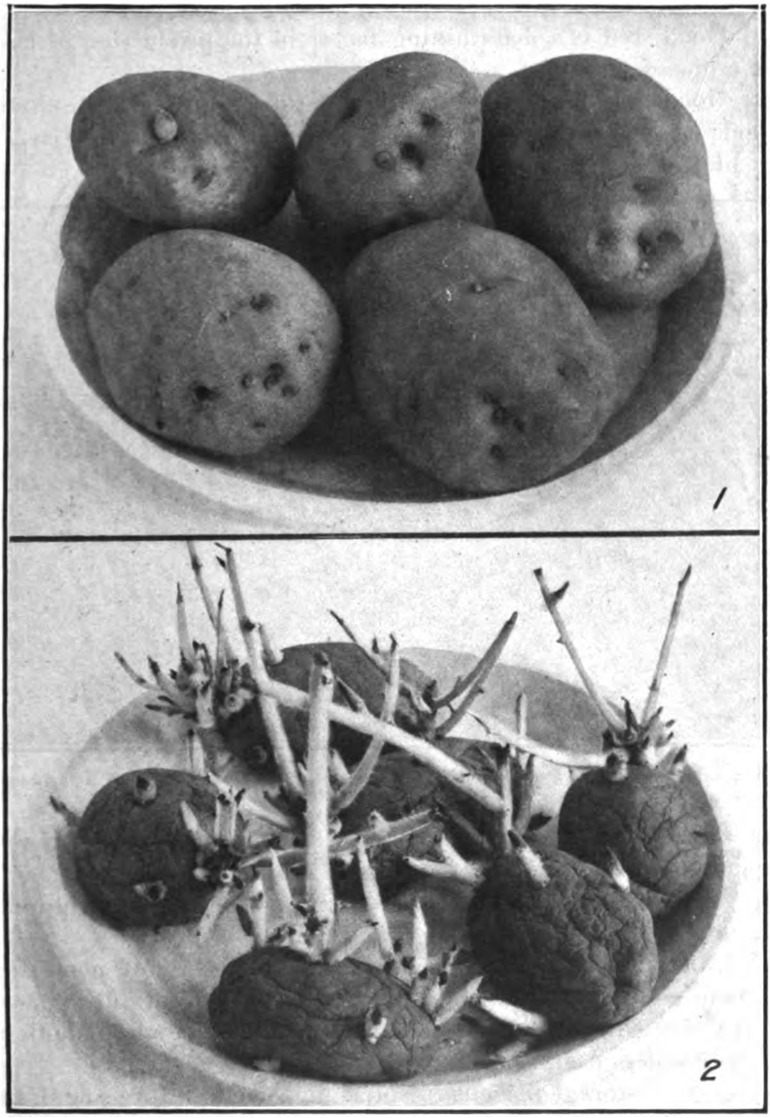

FIG. 7.—Potatoes for seed purposes, showing different stages of germination: 1, Desirable; 2, undesirable.

for later use. The treated tubers should on no account be allowed to come in contact with receptacles, such as old sacks and barrels, in which diseased seed has been handled, as they are almost certain sources of reinfection.

SUMMARY.

(1) Good seed is a determining factor in the production of maximum crops of potatoes.

(2) Good seed may be obtained by the tuber-unit and hill-selection methods of selection through the elimination of unproductive and weak plants.

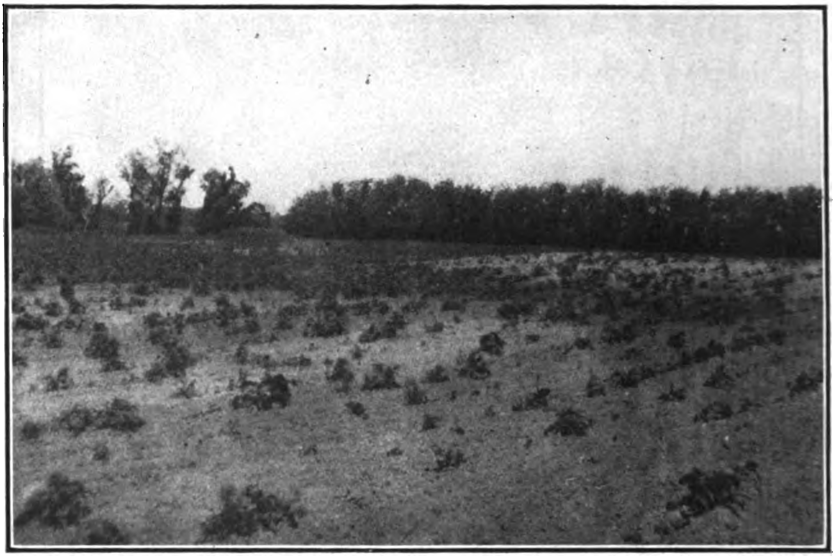

Fig. 8.—A poor stand of Irish Cobbler potatoes, largely due to poor seed and improper handling.

(3) Like produces like. If tubers from unproductive or weak plants are used, a similar harvest will be reaped.

(4) All tubers showing marked discoloration of the flesh should be rejected.

(5) Purity of seed stock is an essential quality of good seed. Serious losses are sustained by the grower through mixtures.

(6) A more liberal use of seed will generally result in both increased production and profit.

(7) A good storage place is essential in order to insure sound, firm seed at planting time.

(8) The use of high-grade seed would increase the returns from the potato crop of the country by many millions of dollars.

(9) All seed should be treated with formalin before planting.

○

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Issued May 2, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 534.

DURUM WHEAT.

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BY

CECIL SALMON, *Plant Physiologist*,
AND
J. ALLEN CLARK, *Scientific Assistant*,
Office of Cereal Investigations, Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., March 11, 1913.

Sir: I have the honor to transmit and to recommend for publication as a Farmers' Bulletin the accompanying manuscript, entitled "Durum Wheat," prepared by Messrs. Cecil Salmon, Plant Physiologist, and J. Allen Clark, Scientific Assistant, under the direction of Mr. Carleton R. Ball, Acting Cerealist in Charge of Cereal Investigations.

This wheat is one of the valuable plant introductions made by the Department of Agriculture. Its productiveness and resistance to drought and disease have made it a popular wheat in the semiarid plains, while its value for making flour and macaroni has finally overcome the early opposition of the milling trade and the prejudice of buyers.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. D. F. Houston,
Secretary of Agriculture.

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DURUM WHEAT.

INTRODUCTION.

As far as known, the first introduction of Russian durum wheat into the United States was by the Department of Agriculture in 1864. This and later introductions were tested under humid conditions, which resulted in a poor quality of grain, and they soon disappeared from cultivation.

The beginning of the durum-wheat industry in this country was made in 1898, when Mr. Mark Alfred Carleton, Cerealist of the Department, went to Russia in search of drought-resistant cereals for the dry lands of the West. This search was resumed in 1900. Many varieties of durum wheat were obtained, among them the Kubanka, which has proved so well adapted to the northern Great Plains area. The new introductions soon became popular among the farmers of that section, but the milling trade strongly opposed the grain on account of the difficulty of milling and the belief that durum wheat was of value only for the making of macaroni and similar products.

Production increased so rapidly, however, jumping from 60,000 or 70,000 bushels in 1901 to about 6,000,000 or 7,000,000 bushels in 1903, and probably about 50,000,000 bushels in 1906, that the development of the market did not keep pace with the increased production. For this reason the price, which had always been below that of common wheat, dropped to even lower levels, the difference sometimes amounting to 20 or 25 cents a bushel. This low price so discouraged the growers that the production in 1909 was slightly less than 40,000,000 bushels. Severe drought reduced the quantity produced to 24,000,000 bushels in 1910 and 16,000,000 in 1911. In 1912 the production was again normal at about 40,000,000 bushels.

CHARACTERISTICS.

Botanically, durum wheat (*Triticum durum*) is very closely related to the common wheats which comprise the principal wheat crop of this country. The durum varieties are all spring wheats, at least so far as known. It has been possible to grow some of them as winter varieties at the Amarillo Cereal Field Station in Texas, at the Nephi substation in Utah, and at southern field stations. When thus fall sown, none of them has proved equal to the standard winter common wheats.

Durum wheat differs from the other spring wheats in size and character of both plant and grain. The plant is usually taller and more vigorous than common wheat, has wider leaves, and generally matures earlier. The heads are broader and more compact, and are often shorter. The beards of durum wheat are exceptionally long and stiff, which, with the shape and compactness of the head, give the plant much the appearance of barley, for which it is often mistaken by those not familiar with the crop. The grains are large and, as indicated by the name "durum," are very hard. The usual color of the grain is clear amber as contrasted with the reddish color of the spring and winter common wheats. There are, of course, wide variations between different varieties in the size, shape, color, and general appearance of both plant and grain. The varieties in general cultivation (Kubanka and Arnautka) have smooth yellowish chaff and yellowish beards and clear amber kernels. Others have black chaff and black beards; the chaff may be smooth (Black Don) or velvety (Velvet Don). There are also numerous forms between these yellow and black groups, and still others with white chaff and white beards.

The durum wheats are less subject to smut and rust and are more drought resistant than the spring common wheats. On the other hand, the quality of the grain is lowered when grown in humid areas or in seasons that are abnormally wet. The compactness of the head prevents rapid drying after rains or heavy dews, which makes durum wheat more subject to attacks of scab in damp, rainy weather.

The advantage most often claimed for durum wheat is its drought resistance. Having been grown apparently for many centuries subject to severe droughts, it has developed those qualities which make it admirably fitted for such conditions. Durum wheat owes its value for areas of low rainfall to its rapid, vigorous growth, early maturity, resistance to drought and disease, and resulting productiveness. On the other hand, the long, stiff beards are such a source of discomfort in handling that many farmers object to the crop.

VARIETIES.

The Department of Agriculture has introduced and tested a large number of varieties of durum wheat. These have been received under 70 or 80 different names and include more than 200 separate importations. These have been tested either independently or in cooperation with the State experiment stations.

KUBANKA AND ARNAUTKA THE LEADING VARIETIES.

The Russian varieties, Kubanka and Arnautka (fig. 1), have proved generally superior to all others. The Kubanka has proved especially well adapted to the drier western portions of the northern Great Plains area, while the Arnautka has proved best adapted to the more humid eastern portion of the same area. Tests conducted at the State experiment stations at Brookings, S. Dak., Fargo, N. Dak., and at the Edgeley and Langdon substations in North Dakota all show the superiority of the Arnautka variety for the eastern parts of these States and for the adjacent portion of Minnesota. On the other hand, tests conducted at substations in the central and western portions of the Dakotas show an equal superiority for the Kubanka. These varieties have proved excellent yielders also in northeastern Colorado and in the Judith Basin of Montana, though closely related varieties, such as Beloturka, Yellow Gharnovka, and Pererodka, have so far slightly exceeded them in yield.

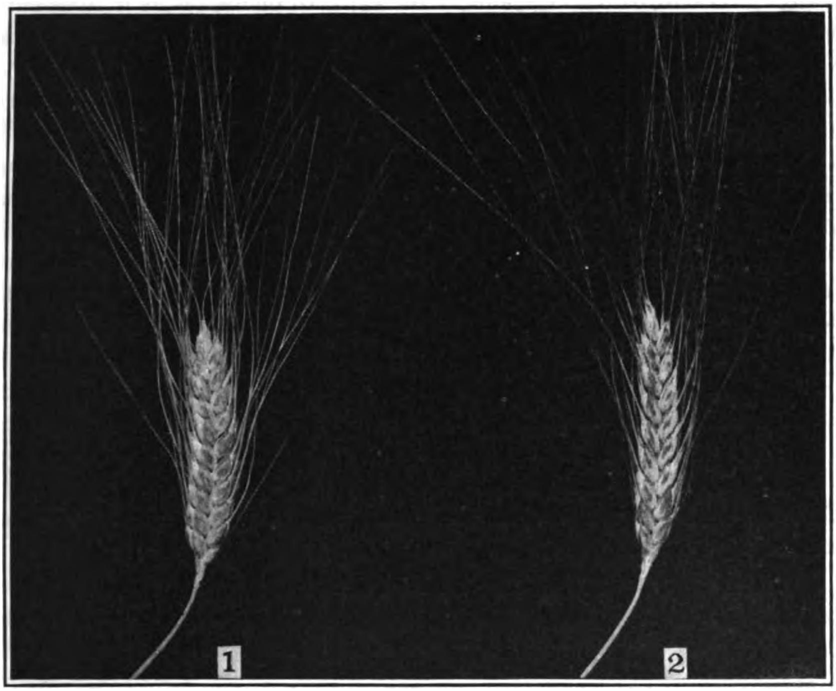

FIG. 1.—Heads of the (1) Kubanka and (2) Arnautka varieties of durum wheat.

An interesting and important relationship seems to exist between the adaptation of these varieties in the United States and in the Russian provinces from which they were imported. In Russia the Arnautka variety is largely grown only in the territory bordering the Sea of Azov and extends only a short distance outward therefrom.[1] The rainfall near the seacoast is about 20 inches annually, varying in different localities and decreasing rapidly toward the interior. Beyond this narrow strip the climate is drier and the conditions on the whole much more severe. In this interior region the Kubanka is generally grown and is a more satisfactory variety.

The rainfall of the eastern portion of North Dakota and South Dakota, where the Arnautka wheat has given the best results, is practically the same as that of the territory bordering the Sea of Azov. Westward in the Dakotas the rainfall decreases as it does outward from the Sea of Azov, and here, as in Russia, the Kubanka variety has proved superior.

The Kubanka and Arnautka varieties are very similar in appearance. Both have long yellowish beards and smooth yellow chaff. The grain of both is of a clear amber color and very hard. The heads of the Kubanka are shorter and broader (see fig. 1), and the grain is usually shorter and plumper. It is difficult to distinguish between the two varieties unless they are grown side by side, the influence of different environments often obliterating varietal differences. The differences in appearance of the Kubanka and Arnautka varieties are so small that about the only way a farmer can be certain of getting the one he wants is to obtain seed from his State experiment station or some other reliable source. The Arnautka variety is usually more rust resistant than the Kubanka, which may account for its higher yields in eastern North Dakota and South Dakota, where rainfall and rust infection are greater than farther west.

AREA TO WHICH ADAPTED.

According to the census of 1910, 87.5 per cent of the durum wheat produced in the United States in 1909 was raised in North Dakota and South Dakota, and probably about the same proportion holds true for 1910, 1911, and 1912 (fig. 2). Minnesota ranks third in production, with about 7 per cent of the total crop. Practically all of the remaining 5 or 6 per cent is grown in Nebraska, Kansas, Colorado, Wyoming, and Montana.

CHIEF PRODUCING AREA.

The area of greatest production is in southeastern North Dakota and northeastern South Dakota, extending slightly into Minnesota. Durum wheat was first extensively tested and distributed in the area where it is now most largely grown. The farmers of this section became acquainted with its value and continued growing it when others refused because of the lower price offered for durum wheat. A second area of smaller extent and much smaller production includes northwestern Kansas, northeastern Colorado, southeastern Wyoming, and western Nebraska. In other portions of Wyoming and also in Montana there are certain districts where a considerable part of the wheat grown is durum.

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[1] Carleton, M. A. Macaroni wheats. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 3, 1901, pp. 11, 12.

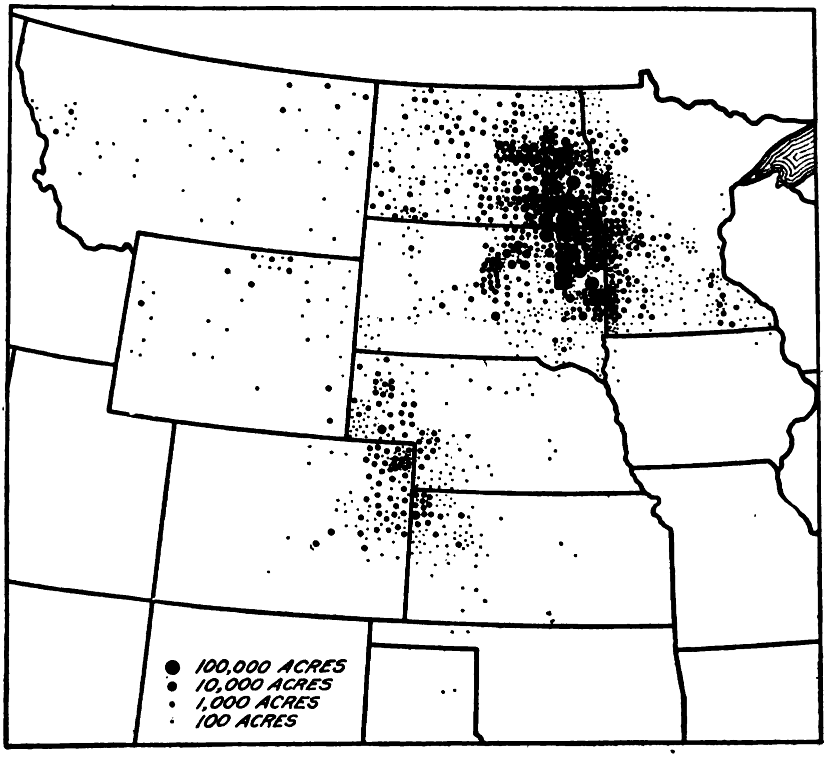

FIG. 2.—Map of a portion of the United States showing the acreage of durum wheat in 1909, as reported by the census of 1910.

FACTORS AFFECTING INCREASE IN AREA.

In the western portion of the Great Plains area, from western South Dakota and adjacent Montana south to the Panhandle of Texas, durum wheat comes into competition with both winter and spring common wheats. The results so far obtained show that wherever winter wheat can be successfully grown it is more satisfactory than any spring wheat. The introduction of hardier varieties and a better understanding of the cultural requirements of winter wheat have permitted growing it in areas formerly thought entirely unsuited to its production. In many cases it has almost entirely supplanted spring wheat. In this portion of the Great Plains area, therefore, winter and spring wheat are contending for supremacy, with the advantage in favor of winter wheat. It is also an area in the process of transition from the open range to small farms and ranches. The raising of feed for live stock requires much of the attention of the farmer, and the growing of money crops, such as wheat, is of less importance here than elsewhere. These factors influence to a great extent the possible future production of durum wheat in this area. At present the production is very small compared with that in the eastern portion of the Dakotas.

Much of this portion of the Great Plains was settled when the difference in price of durum and common wheat was greatest, in many cases sufficient to more than offset the advantage in yield of durum over spring common wheat. The strong dislike to growing wheat with long, stiff beards, such as are present on durum wheat, also often outweighed what was then considered a questionable gain from higher yields but lower prices. The difficulty of obtaining reliable seed at a reasonable price when wanted has often prevented the growing of durum wheat. These are probably the main reasons for the relative unimportance of durum wheat in some districts where it is undoubtedly superior to spring common wheat and where winter wheat can not be successfully grown.

Durum-wheat production in the future depends (1) upon the extension of wheat as a money crop in the Great Plains area; (2) upon the extent to which winter wheat will take the place of spring wheat; and (3) upon the comparative prices of common and durum wheat.

YIELDS.[1]

Experimental tests to determine the yield of durum wheat as compared with common wheats have been conducted by the Department of Agriculture and the State experiment stations for several years in areas where it was thought that durum wheat might be adapted. In general, the duration and agreement of the tests are sufficient to permit the drawing of certain definite conclusions.

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[1] Most of the data on yields presented in figure 3 and discussed herein were obtained from cooperative experiments of the Office of Cereal Investigations. Those for Hays, Kans., are from unpublished records of the Office of Dry-Land Agriculture, which kindly permits their use. Published results from the State experiment stations were used for the following places:

Nebraska, North Platte.—W. P. Snyder and W. W. Burr, "Growing crops in western Nebraska," Nebraska Experiment Station Bulletin 118.

South Dakota, Brookings.—Clifford Willis and W. L. Burlison, "Progress in wheat investigations," South Dakota Experiment Station Bulletin 128.

North Dakota, Edgeley.—O. A. Thompson, Annual Reports, Edgeley Experiment Substation, 1903 to 1910.

North Dakota, Fargo.—J. H. Shepperd and O. O. Churchill, "Cereal crop experiments," North Dakota Experiment Station Bulletin 75.

North Dakota, Langdon.—E. D. Stewart, Annual Reports, Langdon Experiment Substation, 1909, 1910, 1911.

Montana, Billings, Forsyth, Glendive, Great Falls, and Harlem.—Alfred Atkinson and J. B. Nelson, "Dry-farming investigations in Montana," Montana Experiment Station Bulletin 83.

Figure 3 shows graphically the comparative yield of durum and spring and winter common wheats at a number of stations in the Great Plains area. Owing to differences in the duration and method of the experiments, the results at one station should not be directly compared with those at another.

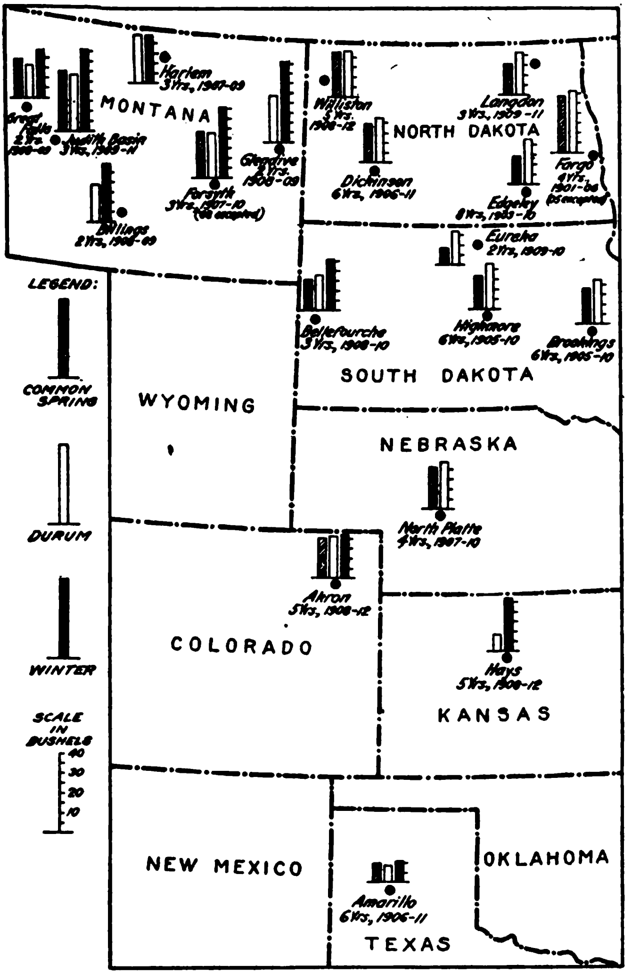

FIG. 3.—Comparative yields of durum and spring and winter common wheats at 19 field stations in the Great Plains area.

As shown by figure 3, durum wheat has its greatest advantage in central and eastern North Dakota and South Dakota, where the largest acreage is now grown. Eight years' results at Edgeley, N. Dak., and six years' results at Highmore, S. Dak., show that the best durum varieties produce on an average from 40 to 50 per cent more grain than is obtained from the standard Fife and Bluestem varieties. The difference is much greater in dry seasons, to which the durum wheat is better adapted than is the common wheat.

Taking this section as a center, the advantage of durum over common spring wheat decreases in a general way as one goes outward. In extreme eastern North Dakota and South Dakota and in western Minnesota, which constitute the more humid part of the durum-wheat area, a gain of from 15 to 25 per cent for durum wheat can usually be obtained. In dry years, or when rust is prevalent, the yield of durum wheat is often double that of the standard common varieties. However, the growing of durum wheat in this area is always at the risk of a deterioration in quality of the grain, which is almost certain to occur in wet seasons. This fact must be considered in determining the final value of durum wheat for this area.

Northward toward the Canadian boundary the advantage of durum wheat becomes gradually less, though it still outyields the common wheats. The temperature and evaporation decrease to the north, which makes the conditions more favorable for the production of common wheats. In Canada, Fife and other common wheats are considered better than durum wheat.

In western North Dakota and South Dakota the results show a gain in yield for durum wheat of about 15 per cent as compared with spring common wheat. The tests in Montana, all of which are of short duration, show that durum wheat outyields the standard varieties of Fife and Bluestem spring common wheats, but has been exceeded slightly by two new varieties, the Ghirka and the Galgalos. At the Amarillo station in the Texas Panhandle, the Galgalos has also outyielded durum wheat.

As previously stated, winter wheat is more profitable than durum wheat wherever it can be successfully grown throughout the western part of the Great Plains area. In western North Dakota, fall-sown wheat generally winterkills. In western South Dakota and eastern Montana, tests of short duration indicate an advantage for winter wheat in certain sections. From western Nebraska and eastern Colorado southward, winter wheat has given uniformly better results than any spring wheat. (See fig. 3.) The advantage of winter wheat is greatest in central and western Kansas and Oklahoma.

Throughout this area, when the soil is too dry to permit the sowing of winter wheat with safety or when a stand is destroyed by winterkilling or some other cause, durum wheat may be grown to advantage. It should not be used, however, to reseed a field of winter wheat which is only partially killed, as the resulting mixture is more objectionable on the market than a mixture of spring and winter common wheat.

COMPARATIVE VALUE.

The market value of durum wheat, as of other classes, depends upon supply and demand. In the United States until very recently durum wheat has sold for less than have equal grades of common wheat. When introduced it was thought the principal demand would come from American and foreign mills engaged in the manufacture of macaroni, and little or no attention was given the possibility of utilizing the flour for bread making. Soon after its introduction attention was called to the suitability of durum flour for this purpose and its use was strongly encouraged. The development of a market has been slow, due mainly to opposition on the part of the millers. However, the use of durum flour has constantly increased, especially for blending with flour from softer wheats. American-grown durum wheat is now being utilized to a large extent for this purpose, both in this country and in Europe. The present demand is due mainly to this fuller appreciation of the value of durum wheat.

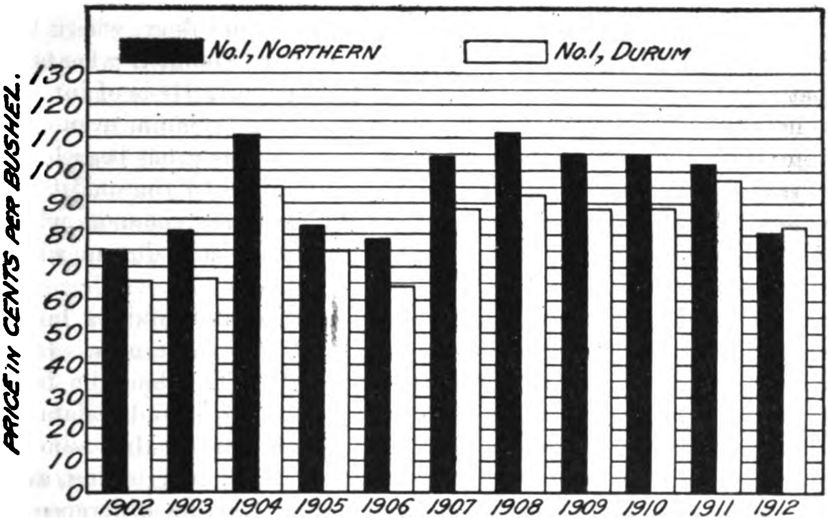

FIG. 4.—Comparative prices of No. 1 durum and No. 1 northern wheats at Duluth, Minn., on December 1, for the years 1902 to 1912, inclusive.

The first quotations for durum wheat on the Duluth market were in 1902, the price for the crop of that year ranging about 5 to 10 cents below equal grades of common spring wheat. Figure 4 shows that up to 1911 the difference in price has usually been greater than that amount. The difference at primary markets and at other times of the year was often greater than shown in the diagram. Beginning with 1908 there has been a steady increase in value as compared with common wheat. The change was small in 1909 and 1910, but beginning with January, 1911, the rise has been rapid, with few downward fluctuations, reaching the highest point in 1912 with a premium over the best grades of hard common wheats.[1] This seems to indicate a more permanent change in price levels than would be the case if the rises alternated with frequent and sudden drops.

The market value of durum wheat compared with common wheat in countries where it is widely grown has been pointed out in a previous publication[2] of this Department. The trend of prices in this country lends special interest to the subject at this time. It has been shown, for example, that at least 80 per cent of the best bread consumed in Russia is made from Kubanka durum flour, where this wheat commands a higher price than the hard common wheats of that country either for local consumption or export. It is of interest to note that durum wheat in Russia is still at a premium over common wheat, the price often being as much higher as it has been lower in this country. This is not due to a difference in the quality of wheat from the two countries, since Russia raises common wheat fully equal to that produced in the United States and durum wheat that is no better than ours.

Both durum wheat and the flour made from it contain a larger proportion of nitrogenous or muscle-building substances. It is usually conceded that the bread made from durum flour, or from blends with other flours, is both highly nutritious and palatable. Durum wheat weighs more to the measured bushel than similar grades of common wheat, but requires more power in grinding, as it is considerably harder than common wheat. A like difference in hardness exists between soft winter wheats and the hard spring common wheats of the Northwest, yet no miller discriminates against the latter on this account. All available data indicate that durum wheat has a value at least equal to that of the best grades of common wheat.

USES.

Durum wheat is used chiefly in the manufacture of a coarse granulated flour called semolina and of ordinary flour for bread making.

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[1] The premium of durum wheat over hard spring common wheat has steadily increased from the value given on December 1, 1912, as shown in figure 4. On April 15, 1913, No. 1 durum sold on the Minneapolis market at a premium of 6¼ cents over No. 1 northern, and on the Duluth market at a premium of 8½ cents over No. 1 northern.

[2] Carleton, M. A., and J. S. Chamberlain. The commercial status of durum wheat. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 70, pp. 10–12, 1904.

The flour is employed either alone or in blends with other flours. This wheat has also a limited use for cereal breakfast foods and during years of large production and low price has often been used for stock feeding. From semolina, the edible pastes, such as macaroni and spaghetti, are made. The consumption of these products has increased greatly during the past two decades, both at home and abroad. Until recently the quantity consumed in the United States was entirely imported, but the increasing demand has attracted manufacturers and at present about 100,000,000 pounds of macaroni are made annually from home-grown durum wheat. This quantity supplies only about one-half the demand for this product. The industry is growing rapidly, however, and the products are being widely advertised as "the best in the world," "made in America from American-grown wheats," etc. While these products have wide use, the demand is small compared with that for bread.

Experimental evidence has shown that the best varieties of durum wheat, such as the Kubanka and Arnautka, yield as high a percentage of flour as do the best common wheats, although the percentage of high-grade flour is less. The percentage of shorts is greater, while that of bran is less from durum than from common wheat. The hardness of the durum kernel increases the cost of milling. Millers have estimated the cost of grinding to be 15 cents a barrel more than for hard common wheat. The baking qualities of durum flour are high. It contains more crude protein than do the flours from other classes of wheat. The color of durum flour is yellower than that from other wheats, and by some people this color is held to be objectionable.

When baking with durum flour the only difficulty experienced is that the dough is sticky and less easy to handle. It is not otherwise difficult to make good bread from this flour. The bread is yellower in color and the volume of the loaf is less, but the absorption or strength of the durum flour is in most instances higher than that of common wheat flours. This results in more loaves from a barrel of flour. The consensus of opinion is that the bread has as good, if not better, flavor than bread from common wheat flour, for it has a distinct nutty taste and is slightly sweeter. Bread from durum flour holds moisture better than that from other flours.

Durum flour is of great value in blends and its use for this purpose is increasing. Excellent results in bread making are obtained by blending this flour with flours from spring wheat, hard winter wheat, and soft winter wheat. The successful blend does away with the stickiness of the dough, lightens the color, and increases the volume of the loaf.

CULTURE.

The culture of durum wheat differs in no way, except possibly in the rate of seeding, from that of other spring wheats in the same area. Durum wheat tillers less than spring common wheat, and the kernels are larger, so that with the drill set to seed at the same rate a thinner stand will be obtained. On the other hand, durum wheat produces more kernels to each head, which at least partially makes up for the thinner seeding. A common practice is to seed about 1 peck heavier than is usual with common wheat, though some seed at the same rate. The best rate of seeding depends largely upon the local conditions of soil, moisture, and seed bed. With good seed and favorable conditions, from 3 to 5 pecks per acre will give the best average results.

IMPROVEMENT OF THE CROP.

The expansion of the durum-wheat industry depends in part upon a continued effort for the improvement of the crop, both in yield and in quality. Further importations may prove of value, but the work already accomplished has shown the superiority of certain varieties and their adaptation to distinct sections. As a rule, farmers will find it to their advantage to grow only those varieties which have proved to be the best. It is very seldom that new varieties offer any advantages. Pure seed of the best variety should be obtained and kept as pure as possible. If thorough cleaning and grading of the seed is practiced each year the yield and quality of the crop will be maintained. Enough of this seed should be carried over from year to year to guard against its complete loss in case of crop failure. Good home-grown seed is usually better and much safer than that of unknown or distant origin. Durum-wheat seed should not be allowed to become mixed with the common wheat, as such mixtures are very objectionable to the millers and result in materially reduced prices for the crop.

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SUGAR AND ITS VALUE AS FOOD.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., March 19, 1913.

Sir: I have the honor to transmit herewith an article on sugar and its value as food, prepared by Mrs. Mary Hinman Abel, who has made an extended study of the subject, taking into account the results of laboratory research as well as household experience. The work of the Bureau of Chemistry of the department has been drawn upon, and also the results of nutrition investigations of the Office of Experiment Stations.

Sugar is an important and useful foodstuff, and information regarding it is very commonly requested from the department. It is believed that this summary of available information concerning sugar and its value as food will prove useful to housekeepers and others interested in the subject.

The bulletin is similar in its general character to other farmers' bulletins on the nature and use of food materials and, like them, has been prepared under the general supervision of C. F. Langworthy, chief of nutrition investigations of the Office of Experiment Stations.

In its present form this bulletin is an extension and revision of an earlier farmers' bulletin (Farmers' Bulletin 93, "Sugar as Food"), which it is designed to replace.

A. C. True, *Director.*

Hon. David F. Houston,
Secretary of Agriculture.

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SUGAR AND ITS VALUE AS FOOD.

INTRODUCTION.

The pleasant flavor of sugar, together with what is now known of its nutritive value, will account for its great popularity as a food. It may almost be said that people eat as much sugar as they can get, and that the consumption of sugar in different countries is in general proportional to their wealth.

The English-speaking people are the largest consumers of sugar. In 1910 England consumed 86.3 pounds per capita and the United States 81.6 pounds, although still larger amounts are said to be consumed in sugar-growing districts, largely in the form of the ripe cane. Denmark that year consumed 77.7 pounds per capita; Switzerland, 64.3 pounds; and Germany, France, and Holland each about 40 pounds; while in Italy, Greece, and Servia the rate was only about 7 pounds per capita. The consumption of sugar is everywhere increasing.

CHEMICAL COMPOSITION OF SUGARS.

The term "sugar," as here used without qualification, means the ordinary sugar of commerce, the chemical name of which is sucrose. Because this was first manufactured from sugar cane it is called cane sugar, but the same sugar is manufactured from beets and is known as beet sugar. It is also found in the juice of many other plants. There are other sugars which are also given popular names denoting their origin—for instance, milk sugar, grape sugar, and fruit sugar. The sugars may be conveniently divided chemically into several groups according to the number of carbon atoms which they contain. The most important from the standpoint of food value are the single sugars, grape sugar (dextrose) and fruit sugar (levulose), with 6 carbon atoms; and the double sugars, cane sugar (sucrose), milk sugar (lactose), and maltose (malt sugar), in which the molecule contains 12 carbon atoms, or twice as many as in the single sugars.[1]

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[1] The brief statement of the chemical nature and names of different sugars and other carbohydrates which follows will perhaps make clear to housekeepers, as well as to others who are interested in such questions, this interesting part of the chemistry of food.

Carbohydrates are so named because they are composed of the elements, carbon, hydrogen, and oxygen, the hydrogen and oxygen being in the same proportions as in water, which is composed of 2 atoms of hydrogen to each atom of oxygen. Though there are carbohydrates with fewer than 6 and with more than 6 carbon atoms, the principal carbohydrates used as food contain 6 carbon atoms or multiples of 6. These

By a chemical process called inversion, which may occur in different ways (see pp. 9 and 17), one molecule of the double sugar is made to unite with water and form two molecules of single sugar. In nature two single sugars, dextrose and levulose, often occur in equal proportions, and the combination is then referred to as invert sugar.

Sugar belongs to the important group of food constituents, carbohydrates, so named because as a whole they contain the element carbon in chemical combination with oxygen and hydrogen, these two elements being in the same proportion as in water. Other carbohydrates closely related to sugar are starch and crude fiber, or cellulose. Sugars and starches are very important foodstuffs, since with fat they supply the bulk of the energy of the diet. Crude fiber, usually digested by man in limited quantities only, is, nevertheless, an important foodstuff, since it adds bulk to the diet.

CHARACTERISTICS OF CANE SUGAR.

Pure cane sugar consists of a mass of white crystals (e. g., the old fashioned "rock candy") easily soluble in about half their weight of cold, or in a small quantity of hot water. Cane sugar is about two and one-half times as sweet as grape sugar.

At 320° F., considerably above the boiling point of water (212° F.), sugar melts into a colorless liquid which rapidly takes on an amber hue. If it is then cooled quickly it hardens into a glassy mass, transparent and brittle, which is called "barley sugar." If heated to a higher temperature it browns, becoming less sweet and acquiring a somewhat bitter flavor. This browned sugar is called caramel. Old-fashioned brown sugar owed its color and flavor, at least partly, to caramel, for the process of manufacture formerly used involved evaporation over an open fire, which caused some of the sugar to become caramelized or half burnt, since in the final stages of sugar making the mass became so thick that it could not move about freely, and the layer next to the bottom of the kettle was raised far above the boiling point.

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are (1) monosaccharids (single sugars), including hexoses (such as dextrose, or grape sugar, and levulose, or fruit sugar), so called because the molecule contains 6 atoms of carbon with 12 atoms of hydrogen and 6 atoms of oxygen; (2) disaccharids (double sugars, such as cane sugar, and lactose, or milk sugar), so called because the molecule contains two of the simple sugar molecules less one molecule of water, namely, 12 atoms of carbon with 22 of hydrogen and 11 of oxygen; and (3) polysaccharids (such as starches), so called because the molecule contains repeated many times the simple sugar molecule minus the molecule of water or 6 atoms of carbon, with 10 of hydrogen and 5 of oxygen. When a molecule of water combines chemically with a molecule of the second group, two hexose molecules are formed, and when the necessary number of molecules of water combine chemically with a molecule of the third group, two or more hexose molecules are formed. This process, called inversion or hydrolysis, may occur in several different ways.

Each group of sugars contains a number of members; for example, grape sugar and fruit sugar have the same chemical formula and the same percentage of carbon, hydrogen, and oxygen, although they are not identical substances. The difference in their properties is due to different groupings of the atoms. This must not be confused with the fact that the same sort of sugar may be obtained from widely different sources. Thus grape sugar is found in grapes and other fruits, and cane sugar is found in the juice of the sugar cane, beets, carrots, and other plants.

CHARACTERISTICS OF OTHER KINDS OF SUGAR.

Dextrose and Levulose.

Besides cane sugar, the commonest kinds are dextrose or grape sugar, very much less sweet than cane sugar, and levulose, very much sweeter than dextrose. These two sugars are usually found together. Dextrose may be seen in yellowish grains in the raisin and other sweet dried fruits. It exists in small quantities in many fruits, but occurs chiefly as a manufactured product, a result of the hydrolysis of starch, which means causing it to unite chemically with water by heating it with dilute acids or in some other way to induce hydration. By this treatment cane sugar is split up into a mixture of dextrose and levulose known as "invert" sugar, which is also a commercial product. Honey is practically a natural form of invert sugar in which there is usually more levulose than dextrose.

More sugar is supposed to be required to sweeten acid fruits if it is added before cooking than if it is added afterwards, and this is ascribed to the change of the cane sugar into invert sugar under the influence of the acid and heat. Miss Jennie H. Snow[1] found that the amount of sugar inverted depends upon the length of time it is cooked and the degree of acidity, and her conclusions are borne out by the results of European investigators. She found, however, that loss of sweetness due to cooking sugar with acid fruit is so slight as to be of little practical consequence. The effect of heat and acids in "inverting" cane sugar, as it it is termed, and also in destroying these sugars, has to be kept in view constantly in the manufacture of sugar. By the slow methods formerly in use on the sugar plantations, the juice of the cane soured before it was boiled, and the acids so formed inverted much of the cane sugar under the influence of heat. This hindered crystallization, as did also the caramel produced by the overheating of a portion of the juice. The hindering of undesired crystallization by inversion with the aid of a little acid is sometimes very important in sugar making. Similarly, manufacturers of candy know that if they wish to prevent crystallization or "graining" of a concentrated solution of sugar, as in making "fondant" or soft filling, tartaric or other acid must be added to invert some of the sugar.

The change of cane sugar in solution to dextrose and levulose mentioned above may be brought about even in the absence of acid, by the action of heat, or by certain ferments, such as invertase, an enzym of yeast.

Milk Sugar.

Milk contains from 4 to 5 per cent of anotner ımportant sugar—milk sugar or lactose. When separated and purified it is a crystalline product and is sold in that form. It is said to be the most readily digestible sugar and is often found in prepared foods, especially those made for invalids and children. It is much less sweet than cane sugar.

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[1] Jour. Hom. Econ., 1 (1909), No. 3, pp. 261-266.

Honey.

Before sugar was a common commercial product, honey, stored by the honeybee, was very generally used to sweeten foods. Although its use for this purpose is much less common since cane sugar has become so plentiful and cheap, honey is still highly prized as a wholesome sweet food and is used either alone or with other foods in a great many ways. It consists of a natural mixture of dextrose and levulose (about 37 per cent of each) and may contain as high as 6 to 8 per cent of sucrose. An average analysis shows 74.41 per cent of reducing sugar calculated as invert sugar, and 1.98 per cent of sucrose.[1] It also contains an average of 17.59 per cent of water and 0.23 per cent of mineral matter. Its flavor is due to volatile bodies in the flowers from which it is obtained, some flowers imparting a more agreeable flavor than others to the honey. It was formerly assumed that its composition was practically the same as that of the nectar gathered by the bees, but recent investigation shows that the nectar undergoes certain changes in the honey sack of the bee, and that the chemical properties of honey are not quite like those of the nectar. Its behavior in cooking and storing is different from that of the ordinary sugars for reasons not yet thoroughly understood. Honey has been used as a food from the earliest times, and is generally conceded to be wholesome as well as palatable. Prior to the passage of the Federal pure-food law, in 1906, strained honey was very frequently adulterated with commercial glucose (see p. 11) and other materials, such as commercial invert sugar, but since this law went into effect there is little adulteration of this product. Mixtures with glucose and invert sugar are sold, but the law requires that they be so labeled.

Japanese Ame.

A sweet material called ame has been made in Japan since early times from glutinous rice or glutinous millet, sometimes from common rice and rarely from Indian corn or sweet potatoes, by converting the starch they contain into maltose (a double sugar similar to sucrose, lactose, etc.) by the action of an unorganized ferment called diastase. Malt or sprouted barley is generally used to furnish the ferment. The cleaned grain or other material is soaked in water and steamed until the starch grains are broken open and made easily accessible to the ferment. Powdered malt and water in proper proportions are added, and in six or eight hours the diastase converts the starch very largely into dextrin and maltose. The liquid is then filtered and evaporated to the desired consistency, which varies according to the season. One of the forms is a dense, clear, light-colored amber liquid not unlike the best commercial glucose in some of its physical properties. Another form is hard and not unlike a white candy in appearance. Ame has been manufactured in Japan for at least two thousand years, and long before sugar was known it was a favorite flavoring. Even at the present time it is sometimes used instead of sugar in cooking, and it is also a favorite food adjunct for invalids.

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[1] U. S. Dept. Agr., Bur. Chem. Bul. 110.

Malt Sugars.

Several malt preparations, some of them thick like sirup and others more of the consistency of candy, are on the market. These are mixtures of dextrin and maltose coming from the action of diastase on starchy materials. Many commercial products, so-called "predigested" and "malted" products and similar goods, have this material as their basis.

Glycogen.

Glycogen or "animal sugar" is a carbohydrate of the same chemical composition as starch, but with different chemical properties. It is found in small amounts in muscular tissue, and more abundantly in the liver, where it may exist in considerable quantities. It has an important function in nutrition, being stored as a reserve source of energy for the body.

SWEET MATERIALS OTHER THAN SUGAR.

Saccharin, an extremely sweet material, is not a sugar, but is of an entirely different chemical structure, being a benzene compound. Its use in food products was forbidden under the Federal pure-food law.[1] It is quite commonly prescribed in cases of diabetes to satisfy the craving for sweets, as it is believed to be less harmful in such cases than the sugar, the flavor of which it replaces.

There are other chemical substances which are not sugars, but which have a marked sweet flavor. They, like saccharin, are in no sense foodstuffs.

COMMERCIAL GLUCOSE AND OTHER COMMERCIAL PRODUCTS MADE FROM STARCH.

"Commercial glucose," "40 sugar," "80 sugar," and "commercial dextrose" are commercial products of the hydrolysis of starch. The first is a thick liquid, rarely showing crystallization, having a composition of between 30 and 39 per cent dextrose, 40 to 53 per cent dextrin, and about 0.5 per cent ash. The others are solid products varying in percentage of dextrose up to 95 per cent, with small quantities of dextrin.

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[1] U. S. Dept. Agr., Food Insp. Decisions 135, 138, 149.

Commercial glucose is often used as a substitute for sugar in sirups, candy making, preserving, etc. Confectioners maintain that certain kinds of candy can not be made of as good consistency with pure cane sugar as with the addition of some glucose. In such cases it can hardly be considered an adulterant. When it is used as a cheaper substitute for cane sugar, and the goods are sold as cane-sugar products, its use is evidently fraudulent. The present law in the United States requires that sirups, jams, jellies, etc., made with glucose, shall be so labeled. Its nutritive value is practically the same as that of other carbohydrates, and there is no reason to suppose that when properly made it is not wholesome.

SOURCES OF CANE SUGAR.

Cane sugar, beet sugar, sucrose, or simply "sugar," as it is known to commerce and in the household, exists in solution in many vegetable juices. It is found in the stems and roots of the grasses, especially in the sugar cane, sorghum, and cornstalks; in fleshy roots, as the beet, carrot, turnip, and sweet potato; in the sap of trees, as the date palm and sugar maple; in almost all sweet fruits; and in the nectar of flowers. Only in a few of these, however, is the proportion of cane sugar large enough to make profitable its separation from the other substances which these juices hold in solution.

In fact, the cane and sugar beet are the only important sources of sugar (sucrose). Of the world's crop of 16,418,500 tons in 1910–11, 8,321,500 tons were made from cane, and 8,097,000 from the beet.

Sugar is a staple article of food, just as is bread or meat, but few realize that, unlike bread and meat, it has been a staple food for but a few generations. The art of manufacturing it has been developed very rapidly within the last 125 years. Only, indeed, in the last three-quarters of a century has it been produced in such quantities and at such a price as to bring it into really general use.

SUGAR FROM THE SUGAR CANE.

The sugar cane is a gigantic jointed grass with the botanical name *Saccharum officinarum,* native to eastern India and China, numerous varieties of which are now grown in the tropical and subtropical regions of both hemispheres.

Sugar from the sugar cane was probably known in China 2,000 years before it was used in Europe. When merchants began to trade in the Indies, sugar, like spices, perfumes, and other rare and costly merchandise, was brought to the western countries of Europe, and for a long time it was used exclusively in the preparation of medicines. An old saying to express the lack of something very essential was "Like an apothecary without sugar." Several centuries before the Christian Era Greek physicians knew of sugar under the name of "Indian salt." It was also called "honey made from reeds," and was said to be "like gum, white and brittle." But not until the Middle Ages did Europeans have any clear idea of its origin. It was confounded with manna or was thought to exude from the stem of a plant, where it dried into a kind of gum. When in the fourteenth or fifteenth century the sugar cane from India was cultivated in northern Africa, the use of sugar greatly increased, and as its culture was extended to the newly-discovered Canary Islands and later to the West Indies and Brazil, it became a common article of food among the well-to-do. By many the new food was still regarded with suspicion. It was said to be very heating, to be bad for the lungs, and even to cause appoplexy. Honey was thought to be more wholesome, because more natural than the "products of forced invention." The sugar-growing industry in what is now the United States dates from 1751. It has developed into a great enterprise, as has also sugar refining.

SUGAR FROM THE SUGAR BEET.

The sugar consumed in this and other countries up to 1850 was nearly all derived from the sugar cane, but at the present time one-half of the sugar crop is obtained from the sugar beet. Between 1863 and 1883 Germany, one of the leading beet-sugar producing countries, increased its output 338 per cent. It would once have seemed incredible that the kitchen garden should furnish a rival for the "noble plant" that had made the fortunes of Spanish and English colonies, but the cultivation of the beet for sugar has in one generation shifted the center of the sugar industry from the Tropics to the Temperate Zone. This growth has been fostered by strange vicissitudes in the fortunes of nations, such as the commercial embargoes and sugar bounties of the Napoleonic wars, and the abolition of slavery in the British colonies, giving, as it did, a temporary check to the growth of the cane, aided in the creation of the beet-sugar industry. The real creators of the new industry, however, were men of scientific training who solved certain botanical and chemical problems.

In 1747 Marggraf, a chemist of Berlin, discovered that beets and other fleshy roots contain a crystallizable sugar identical with that of the sugar cane. In 1799 the subject was brought before the French Academy, and in 1801 the first manufactory for beet sugar was erected. It had been manufactured as early as 1797, but the 2 or 3 per cent of sugar that could be extracted by the methods then in use was too little for commercial success. A new stimulus was given by the sugar bounties of Napoleon in 1806, and methods improved rapidly, especially in France. Two great difficulties still remained: The percentage of sugar present in the beet was small (5 per cent), and it was only with great difficulty that it could be separated from the many other constituents, some of them acrid and having a very unpleasant flavor. Science now came to the aid of the industry, and a beet was gradually developed with a larger percentage of sugar and a smaller percentage of the undesirable impurities. Eighteen tons of beet roots were necessary in 1836 to produce 1 ton of sugar; in 1850, this quantity was reduced to 13.8 tons; in 1860, to 12.7 tons, and in 1889, to 9.25 tons. From 5 per cent of sugar, as found by Marggraf, the sugar beet of good quality, thanks to the scientific work which has developed it, now contains 15 per cent and more, at least 12 per cent being considered necessary for profitable manufacture.

SUGAR FROM THE SUGAR MAPLE.

The sugar maple of North America is also a source of sucrose, the trees being tapped in the early spring to obtain the sap as it flows upward through the trunk on the way to the branches. This sap on boiling yields its 2.5 per cent of sucrose and a few nonsugars in a more or less moist, brown, crystalline mass, which can be refined until it is like other pure sucrose. However, on account of the pleasant flavor the product in its crude form sells for a better price than would the refined sugar. Five gallons of sap yield about a pound of sugar. Equally popular is the maple sirup; that is, the sap which has been boiled down, but not enough to crystallize.

It is said, apparently on good authority, that maple sugar was made by the American Indians for an untold time before Europeans came to this continent. It is interesting to read a paragraph from a book written by the eminent Robert Boyle and printed at Oxford in 1663:

> There is in some parts of New England a kind of tree * * * whose juice that weeps out of its incisions, if it be permitted slowly to exhale away the superfluous moisture, doth congeal into a sweet and saccharin substance, and the like was confirmed to me by the agent of the great and populous colony of Massachusetts.

Maple sugar was also appreciated in colonial times for making sweets as well as for use as a staple article of diet, for early records mention a "nut sweet" made from maple sugar, butter, and nuts, the sugar being melted and slightly browned in order to impart a caramel flavor in addition to the maple flavor.

Occasionally, by a method similar to that by which maple sugar is obtained, sugar is made, or was made in colonial times, from the sap of the butternut tree, and, it is said, from the birch also.

According to the Preliminary Report of the United States Census for 1910, the total quantity of maple sugar produced in this country in 1909 was 14,060,206 pounds and the total amount of maple sirup was 4,106,418 gallons.

QUALITY OF SUGAR FROM DIFFERENT SOURCES.

The methods used in the manufacture of sugar are all devised to separate the sugar from the other constituents of the juice. The juice containing the sugar is expressed or extracted from the cane, beet, etc., treated to remove the nonsaccharin substances which prevent crystallization, and evaporated in vacuum apparatus to prevent burning; the sugar is then crystallized, and the crystals separated from the molasses in centrifugals. Modified methods of manufacture may produce white granulated sugar direct from the beet or the cane. When these are not used, the product is "raw sugar" which must be passed through some refining process before it is white sugar. The methods of manufacturing sugar from the beet are described in a previous bulletin of this series.[1]

The average composition of raw sugar from a number of different sources is as follows:

Average composition of raw sugar.

Sugar from—	Water.	Cane sugar.	Other organic substances.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Sugar cane	2.16	93.33	4.24	1.27
Sugar beet	2.90	92.90	2.59	2.56
Maize	2.50	88.42	7.62	1.47
Palm	1.86	87.97	9.65	.50
Maple	7.50	82.80	8.79	.91

Raw sugar from these various sources takes on in each case the character of the impurities from which it has not yet been freed. Thus, the raw products of the sugar cane, maize, and the sugar maple, are pleasant in flavor, that of the beet is acrid and disagreeable, while the raw palm sugar or jaggary is of low sweetening power, because of the large amount of invert sugar (dextrose and levulose, see p. 9) that has resulted from fermentation and too high a degree of heat used in evaporation. From all these raw sugars the pure cane sugar, or sucrose, as known to the chemist, can be crystallized out, and in every case the sugar is identical in chemical composition, appearance, and properties. By no chemical test can the pure crystallized sugar from these different sources be distinguished. There is a popular impression to the contrary, however, and it is often asserted that beet sugar has less sweetening power, or that fruits preserved with it do not keep as well, but this can be true only of specimens that have been imperfectly purified.

Tests made at the California Experiment Station[2] led to the conclusion that the two sorts of sugar were equally valuable for canning, and identical in their behavior when of the same fineness of crystallization.

Methods of refining raw sugar have been so improved in the last few years that it may be truly said that few food substances are so nearly pure chemically as the best granulated or lump sugar.

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[1] U. S. Dept. Agr., Farmers' Bul. 52.

[2] California Sta. Circ. 33.

PURITY OF SUGAR.

Of 500 samples of sugar examined several years ago by the Bureau of Chemistry of this department,[1] not one was found to be adulterated. The low price of cane sugar, in comparison with the price of substances that might be used for adulteration, protects it from such attempts.

A more recent publication of the Bureau of Chemistry[2] states that sugars as a class, both the high and low grades as now found on the market, are practically free from adulteration. This is particularly true since the Federal pure-food law of 1906 went into effect.

There is a popular belief that granulated sugar is often adulterated with white sand or finely ground rock, and that pulverized sugar is commonly adulterated with starch or lime dust. Cases of such adulteration, however, have rarely been found by the Bureau of Chemistry, though starch has been detected in a very few samples of powdered sugar. It is a very simple matter to test suspicious sugar for the presence of such materials. Sugar is readily soluble in water, and the sand and mineral adulterants are insoluble. If a spoonful of sugar is added to a glass of water and stirred, it will completely dissolve, while any sand or similar material will remain undissolved. If the water is warm the sugar will dissolve more quickly than otherwise, and care must be taken to continue the stirring for considerable time, as some of the very dry crystalline sugars dissolve rather slowly.

FOOD VALUE OF SUGAR.

The most interesting use of sugar is as a food for the animal body. Within certain limits, sugar may be considered as the equivalent of starch that has been digested and made ready for absorption. A mealy boiled potato, like all forms of starchy food, must be largely converted into some kind of sugar by the digestive juices before it can be absorbed as food.

It is commonly stated that the food eaten by the average adult is at least one-half of vegetable origin, and analyses show that the nutrients of vegetable foods are very largely starch. The average of 400 dietary studies made in the United States shows about 40 per cent animal food and 60 per cent vegetable food. Starch in cereal grains and other foods, and separated as cornstarch, etc., furnishes a considerable part of the heat and muscular power of the body. The summary of data regarding the American diet quoted above shows that sugar constitutes 5.4 per cent of the average diet and furnishes 17.5 per cent of the total energy in it. It is clear that starch, sugar, or any food that will serve the same purpose is of great importance.

To understand the utilization of such foods in the body better, the process of carbohydrate digestion may be considered. When a starchy food, such as boiled potato, is taken into the mouth, it is at once acted upon more or less by a ferment contained in the saliva, and this action is continued by a ferment contained in the intestines. It is broken up into simpler chemical compounds, and it finally reaches the blood and muscles as dextrose, a form of sugar which can be burned in the body to yield muscular energy and heat. When an excess of carbohydrates (sugar or starch) is consumed, the dextrose in the digestive tract is converted in the liver to glycogen and stored until required, being then, it is believed, reconverted into dextrose. More complex changes may take place which convert carbohydrates consumed in excess into fat, which is also stored as a reserve material.

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[1] U. S. Dept. Agr., Div. Chem. Bul. 13, pt. 6.

[2] U. S. Dept. Agr., Bur. Chem. Bul. 100.

Some recent German investigations indicate that the different kinds of sugar are not equally well adapted to increasing the supply of glycogen in the body. In experiments with dogs, sucrose and dextrose proved the most valuable in this respect.

DIGESTION OF SUGAR.

When sugar is eaten it is changed in the digestive tract before it is taken up in the blood and carried where it is needed. If a solution of cane sugar be injected directly into the blood, it is passed out by the kidneys unchanged, showing that it is not fitted for assimilation until it has been changed, as it is in normal digestion. The change needed is slight compared with that required for the digestion of starch, sugar being "inverted" or changed into the simpler sugars as already described (see p. 9), and this change is brought about in the digestive tract by the agency of enzyms or ferments regarding the nature of which little is known. When thus changed into the simpler sugars, its function in the body is similar to that of starch after it has reached the analogous stage in digestion.

At the Minnesota Experiment Station[1] the thoroughness of digestion of sugar was studied with healthy men, 5 ounces per day being consumed as part of a simple mixed diet. The sugar showed a high digestibility, 98.9 per cent of its total energy being available to the body, on the average. In general, it increased the available energy of the whole ration 25 per cent and did not affect the digestibility of the foods with which it was combined. The protein of the ration was more economically used than commonly, the nitrogen retention being increased 25 per cent. It was pointed out in discussing these experiments that "the value of sugar in a ration depends upon its judicious use and combination with other foods."

SUGAR AS A FOOD FOR MUSCULAR WORK.

Food must supply enough protein or nitrogenous material for the formation and repair of tissues and for certain other uses in the body, and in addition sufficient other material to make up the amount of energy necessary for heat and muscular work. The nitrogen-free nutrients are fats and carbohydrates. In the ordinary diet the relative amount of fat and carbohydrates is usually regulated by personal preference. Fat will furnish two and one-fourth times as much energy per pound as carbohydrates. Taking account of this fact it is immaterial on chemical grounds which of these nutrients supplies the necessary energy, although this is not the case from the standpoint of hygiene.

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[1] Minnesota Sta. Rpt. 1903-4.

The main function of sugar as found in the blood, whether resulting from the digestion of sugar or of starch, is believed to be the production of energy for internal and external muscular work, and, as a necessary accompaniment, body heat. This has been amply demonstrated by experiment. By ingenious devices the blood going to and from a muscle of a living animal may be analyzed, and it is thus shown that more blood traverses an active or working muscle and more sugar disappears from it than is the case with a muscle at rest.

To decide the question of the value of sugar as a source of energy for the working muscle, much careful laboratory work has been carried on. It has been found that an increase in the sugar content of the diet, when not too great and when the sugar is not too concentrated, lessens or delays fatigue and increases working power. Increased amounts of sugar were found to increase the ability to perform muscular work to such an extent that on a ration of 500 grams (17.5 ounces) of sugar alone a man was able to do 61 to 76 per cent more work than on a fasting diet, or almost as much as on a full ordinary diet. The addition of about half this quantity of sugar to an ordinary or to a meager diet also considerably increased the capacity for work, the effect of the sugar being felt about a half hour after eating it, and its maximum effect showing itself about two hours after eating. The coming of fatigue was also found to be considerably delayed on this diet, and taking 3 or 4 ounces of sugar a short time before the usual time for the occurrence of fatigue prevented the appearance of it. Lemonade, or other similar refreshing drink, and chocolate have been suggested as mediums for supplying in small doses an extra amount of sugar to men called upon to perform extraordinary muscular labor. The application of these results to the food of soldiers who may be called upon for extraordinary exertion in marching or fighting is very evident. Practical tests of the value of sugar in preventing or delaying fatigue, made in both the German and French armies, indicate the value of sugar in the ration when the men are subjected to great exertion.

It is believed that more decisive results may be obtained by tests with men and animals in which the effects of given quantities of sugar in the diet are compared with those obtained with starch and other food materials. Such experiments have been made under the auspices of this department with men in the respiration calorimeter. This apparatus makes it possible to measure with great accuracy the relation between the material consumed and the muscular work done. In experiments planned to test the value of carbohydrate foods as a source of energy during severe muscular work, the subjects were able to include 350 grams, or about three-quarters of a pound, of cane sugar in their daily diet without any deleterious effects.[1]

According to our present knowledge the value of sugar as a food for muscular work may be briefly summarized as follows:

When the organism is adapted to the digestion of starch, and there is sufficient time for its utilization, sugar has no advantage over starch as a food for muscular work.

In small quantities and in not too concentrated form sugar will take the place, practically weight for weight, of starch as a food for muscular work, barring the difference in energy and in time required to digest them, sugar having the advantage in these respects.

It furnishes the needed carbohydrate material to organisms that have little or no power to digest starch. Thus, milk sugar is part of the natural food of the infant whose digestive organs are, as yet, unable to convert starch into an assimilable form.

In times of great exertion or exhausting labor, the rapidity with which it is assimilated gives sugar certain advantages over starch and makes it prevent fatigue.

This latter quality, which renders it more rapidly available for muscular power, may account for the fact that sugar is so relished by people who are doing muscular work, and by those of very active habits, such as children.

The American farmer ranks high among agriculturists as a rapid and enduring worker, and his consumption of sweets is known to be very large. The same is true of lumbermen and others who work hard in the open air; sugar and sweet cakes are favorite foods with them. Dietary studies carried on in the winter lumber camps of Maine showed that large quantities of cookies, cakes, molasses, and sugar were eaten, sugar of all sorts supplying on an average 10 per cent of the total energy of the diet.

The value of sugar in cold climates, where foods containing starch are not available, is evident, and in the outfit of polar expeditions sugar is now given an important place.

Oriental races are very fond of sweets, as often noted by travelers. Certain forms of confectionery are very popular in Turkey and other regions of the East, and in tropical lands the consumption of dates, figs, and other sweet fruits is very large. In a discussion[2] of the food of the natives of India the great value set on sweetmeats or sugar by the Hindoo population of all classes is pointed out. Large quantities of brown or white sugar are used to sweeten the boiled milk, which is a common article of diet, and sugar is also used with sour milk, rice, cheese, and other foods. It has also been said that the employer who will not furnish the native laborers with the large amounts of sugar they desire in their daily ration must expect to lose his workmen.

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[1] U. S. Dept. Agr., Office Expt. Stas. Bul. 175.

[2] Jour. Trop. Med. [London], 9 (1906), p. 310.

Certain rowing clubs in Holland have reported very beneficial results from the use of large amounts of sugar in training.

Pflüger, who devoted so much attention to glycogen and other carbohydrates, says that undoubtedly sugar in the blood is heavily drawn on during violent exercise; hence the longing for it in a form that can be rapidly assimilated.

Its use by mountain climbers is well known. The Swiss guide considers lump sugar and highly sweetened chocolate an indispensable part of his outfit.

This brief summary serves to show the use which is made of sugar when severe work is performed, and some of the experimental data which indicate that this custom is justified.

SUGAR AS A FAT FORMER.

Sugar, like starch, is fattening; that is, when taken in excess it may be transformed into fat and stored as reserve material. On this account physicians commonly advise that sugar be sparingly used by the corpulent. This advice is given because sugar in the form of candy or other sweets is often taken as an accessory to an already abundant diet.

A practical illustration of the use of sugar as a fattening food is found in the use of both sugar and molasses in fattening farm animals, the fat so produced being found firm and of good quality. In sugar-producing regions it is a common constituent of the rations of horses and mules, and it is fed to dairy cattle and to fattening steers. In Louisiana, for example, it is the usual practice to feed "black strap" molasses to plantation horses and mules at the rate of 8 to 12 pounds per head per day. So common has its use become for farm animals in general that many mixed rations are now on the market which contain molasses as one of their chief constituents. Sometimes the materials added are used principally to absorb the molasses and make it more convenient to feed. The molasses, of course, contains practically no protein, the body-building material, and frequently materials are mixed with it which are rich in this constituent in order that the mixed feed may constitute a well-balanced ration.

SUGAR AS A FLAVOR.

In addition to its value as a food, sugar is important in the diet as a flavor, one which the cook could not easily spare, as it now enters into a great variety of dishes. Indeed its agreeable flavor has always constituted one of the chief reasons for its use, and will continue to do so, even though we make use of the abundance of relatively cheap starchy materials we possess which theoretically may readily take the place of sugar as a food.

In some dietary studies made under the auspices of this department with a club of students at the University of Maine, an investigation was made of the effect of supplying a liberal amount of maple sirup in a diet which contained an abundance of nutrients. The sirup was evidently relished, and considerable amounts were eaten. However, there was not a corresponding decrease in other foods; on the contrary, the amount of flour was in excess of the amount ordinarily consumed. It would seem that the maple sirup, and flour in the form of griddlecakes, were consumed simply on account of their agreeable flavor. Provided the diet contained sufficient nutrients in the first place, this increase was not desirable on the ground of economy, and it may be questioned whether it was desirable from the standpoint of health. When a similar comparison was made of the addition to the diet of liberal quantities of milk, which has a much less distinctive flavor, there was a corresponding decrease in the amount of other foods consumed. This would indicate that much of the sugar used is consumed for its agreeable flavor and not because it is recognized as a food which is required to satisfy body needs.

FOOD VALUE OF TABLE SIRUPS AND MOLASSES.

Sirups of various kinds and molasses have always been used to a large extent in the United States as articles of diet and for cookery. There are several forms in common use. Of these, maple sirup, which is obtained by evaporating the sap of the sugar maple, commands the highest price. Cane sirup made from the expressed juice of the sugar cane is another important sirup, as is also the sirup made from sorghum by methods very much like those used in the manufacture of sirup from sugar cane. Very much used, too, are the homemade sirups obtained by boiling sugar, either white or brown, with water. A little caramel made by burning sugar in a frying pan and dissolving it in water may be added to the sirup to give both color and flavor. Some housekeepers add a little vinegar to homemade sirup, which imparts a flavor and inverts more or less of the sugar. Sometimes water in which several corncobs have been boiled is used in making homemade sugar sirups, the cobs imparting a flavor which many relish and which is said to suggest maple. In Europe a sirup called "whey honey" is made by boiling down, with sugar, the whey drained from cottage (sour milk) cheese until it is thick as honey, the proportions being 1 pound of sugar to a quart of whey. This has a pleasant and distinctive flavor.

An interesting example of the use of molasses in quantity is furnished by the negroes in some regions of the Southern States. Dietary studies in the Black Belt of Alabama showed that the diet was made up almost entirely of molasses, frequently homemade, corn meal, and fat pork.

The different grades of molasses obtained as by-products in the manufacture of sugar from sugar cane have always been popular as table sirups and for cookery. Molasses produced by the open-kettle process of boiling is the most highly appreciated, and for a long time was a staple article for both purposes. Generally speaking, it can now be obtained only in the Southern States and there in small quantities only, since the modern process of sugar making has practically eliminated this open-kettle molasses from the market. To supply its place, the manufacture of sirup directly from the sugar cane and without the separation of any kind of sugar has come to be practiced extensively in the South, particularly in Georgia, Florida, Alabama, Mississippi, and Louisiana. According to an early publication of this department, "this sirup forms a delicious, wholesome, and valuable condimental food substance, the use of which is rapidly extending; and, because of its merits, it appears destined to become a very important food."

For some reason the public has come to judge sirup largely by its color. Many prefer a dark product for cooking, partly because it colors the material with which it is mixed, and partly because the dark color is still associated in their minds with the flavor of old-fashioned molasses. For table use, however, a light-colored sirup is usually preferred. In this case the fact has apparently been overlooked that if properly manufactured good sirup must possess some color, since in the evaporation of the sugar juice in an open kettle or pan a high temperature is employed, which causes an inversion of some of the sugar, and also has a tendency to produce caramel which imparts a color to the sirup. Though a light-colored sirup is popular, a brown color does not mean that the sirup is not of good quality.

There are also in use in this country quantities of table sirups which are simple mixtures, the chief ingredient of which is commercial glucose, and the flavor of which comes very largely from some of the sirups and molasses mentioned above. In certain of these mixtures which owe their flavor and color to "refining sirup," a by-product of the sugar refinery, the content of soluble salts is large enough to impart a distinct saline flavor. The bone black used in purifying the sugar also affects the flavor of "refining sirup." Since the Federal pure-food law was enacted such mixtures bear a label showing the constituents.

Sugar-beet molasses is not used for table purposes, as no way has been found to free it commercially from objectionable impurities.

NUTRITIVE VALUE OF SUGAR CANE.

The entire juice of the ripened sugar cane is, of course, more nearly a complete food than its crystallized sugar, for it contains other constituents besides carbohydrates. It is elaborated by the plant as a rich food for building up young leaves and buds. In sugar-producing countries the cane is regarded as a staple food during its season. All classes of people chew the ripe cane freed from its hard rind, incredible quantities being consumed in this way. Shiploads are brought daily to the markets of Rio Janeiro and West Indian towns. For months the chief food of the negro laborers on the plantations is said to be the sugar cane, and they are seen to grow strong and fat as the harvesting season advances, although they may begin it weak and half-starved.

PRACTICAL USE OF SUGAR IN THE ORDINARY DIET.

Sugar was formerly regarded as a condiment and valued chiefly for its pleasant taste, but its food value has been fully established and, considering the immense quantities at present consumed, it is very important to determine the extent of its usefulness in dietaries.

It has been ascertained that in large numbers of well-to-do families in this country about 2 pounds per week per person are consumed. It would seem that this amount, or about one-fourth of a pound daily, taken in addition to other food, is well utilized by the system. There is some question regarding the desirability of using larger quantities. The use of sugar it would seem should be limited in two ways: (1) The amount consumed should not be greater than may be readily assimilated, else it would overload the stomach and bring on digestive disturbances and in some cases might produce pathological conditions in the excretory organs; and, (2) the sugar should not be taken in a solution or other form so concentrated that it causes a burning sensation or other digestive disturbance (see p. 24). The question of possible permanent injury from the use of fairly large amounts of sugar seems to be an open one, and certainly the extreme views which are sometimes found in popular writings do not seem to be entertained by well-informed physiologists, the conclusion generally accepted being that used in reasonable amounts sugar is both wholesome and nutritious.

AMOUNT AND CONCENTRATION.

Sugar differs greatly from starch in the amount that can be properly used in the system. Starchy foods, such as potatoes, bread, etc., can be digested and utilized in very large quantities. As much as 600 grams (1.3 pounds) of starch per day may be digested for many days without difficulty. This amount of starch is contained in 2.5 or 3 pounds of bread, or in 6 or 7 pounds of potatoes. Fewer tests have been made regarding the maximum amount of sugar that may be used by the system. Vaughan Harley used large quantities of sugar in some of his experiments on himself, but 400 grams (nearly a pound) daily for some time very much affected his digestion.

Since, as scientific investigators seem agreed, the digestion of sugar is relatively so rapid, assimilation and storage in the liver can not keep pace with its absorption from the intestines if it is taken in large quantities. In this case, part of the sugar will be excreted unchanged. Not only is this excess of sugar wasted, but such an unnatural tax on the excretory organs, if constant and long continued, might end in disease. It is also a matter of common observation that large amounts of sugar and sweetened food are apt to be accompanied by undue fermentation in the stomach and intestines. If this occurs it shows that the quantity of sugar eaten is too great.

In this regard, investigators have pointed out that sugar bears much the same relation to starch that peptone, one of the products of meat digestion, does to meat. Both sugar and peptone are very diffusible, and thus enter rapidly into the circulation, strong solutions at the same time irritating the mucous membrane with which they come into contact by virtue of their water-abstracting power. The "furry" feeling noticed when a piece of hard candy is held in the mouth for some time against the cheek is a familiar example of the effect produced on sensitive membrane by a concentrated solution of sugar, which is undoubtedly due to the fact that equilibrium of density is not readily established between the liquid of the two sides of the membrane. The digestive disturbances noted when very concentrated solutions of sugar or other substances are taken into the stomach are attributed to similar causes; that is, to differences in the density of solutions on the two sides of the living membrane.

Doubtless because sugar is commonly excluded from the diet of diabetics the statement has been made that eating sugar is the cause of this disease, which of course does not follow. Such an opinion is not entertained by physiologists, as is apparent from the statement in a recent report[1] of the Connecticut State Agricultural Experiment Station, which shows the fallacy of such a belief. That sugar, honey, sirup, etc., "produce diabetes" would, according to the report, be "startling if true."

It is sometimes said that sugar produces gout. There seems to be no proof of this theory.

Sugar seems ill adapted to the sick, except when used in very small quantities as a flavor. Jacobi[2] remarks that the absorption of sugar is slower by sick than by healthy children, and that in such cases only a little should be given and never in concentrated form. He also states that the conversion of milk sugar into lactic acid takes place very rapidly, while cane sugar is not so readily transformed, and accordingly he insists that the latter be added to the food of infants and children.

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[1] Connecticut State Sta. Rpt. 1911, pt. 2, p. 161.

[2] Therapeutics of Infancy and Childhood. Philadelphia, 1896, p. 16.

When any bad effects can be ascribed to sugar they are usually due to its use in larger quantities than the 3 or 4 ounces a day which seem to be digested by the healthy adult without difficulty. The conclusion to be drawn from such experimental work as that referred to is that overeating with sugar is to be avoided, not, as has sometimes been stated, that sugar is other than a useful foodstuff.

The statement is sometimes made that sugar is unwholsome because it has been separated from the plant and is therefore "artificial." Like a host of other statements of similar popular origin, this is based on belief rather than experience and evidence and is not the view generally held. Bunge[1] has called attention to the lack of calcium (lime) and iron in sugar as compared with honey and sweet fruits. His contention that this might be a possible source of danger does not seem probable when one considers the varied character of our diet and its abundant supply of fruits and vegetables, milk products, and other foods which contain calcium and iron. The object sought is, of course, to supply in the diet all the substances which the body needs, and if this is done by the foods as a whole, the possible lack of a constituent or constituents in some single food which forms a part of the diet is not of importance. If for any reason calcium is lacking in the diet, the deficiency may be easily made good by increasing the amount of milk and milk products. Similarly, iron may be increased, if this is desirable, by taking more fruits, green vegetables, and the coarser milling products of the cereal grains, foods which are within the reach of practically everyone.

It will be noticed that sugar as it exists in nature—e. g., in the sugar cane, in milk, and in most fruits—is not highly concentrated. In milk it constitutes from 4 to 6 per cent. It would seem that the animal organism is best adapted to the utilization of food principles in the somewhat dilute or bulky form in which they occur in the commonly accepted foods—protein as found in meat, milk, etc., starch in grains, and sugar in small quantities at a time as found in vegetable juices and milk and in combination with other foods—and that it does not readily accept unlimited amounts of chemically isolated and purified food principles. Most of the statements which have been made regarding the amounts of sugar which are well tolerated depend upon evidence obtained in experiments in which the sugar was used dissolved in liquid, as in tea, coffee, or some similar way, or from experience of the results which sometimes follow when a large quantity of sirup or candy or some similar product rich in sugar is taken. How far the conclusions drawn would apply to sugar taken in cake, pastry, custards, and other cooked foods can not be stated definitely, as few tests have been made upon the digestibility of such foods. With the exception of thick preserves and some similar foods, in which sugar is used as a preservative as well as a flavor, most cakes, custards, and other foods flavored with sugar contain it in moderate amounts, which means that the sugar is diluted or extended by a considerable quantity of other material. In this connection it may be said that it is the usual custom to take sugar in dilute form, as, for instance, when we add it to tea or coffee, sprinkle it on fruit, add it with milk or cream to breakfast cereals, or use it in other similar ways.

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[1] Ztschr. Biol., 51 (1901), p. 155.

SUGAR AND THE TEETH.

It is often said that sugar is harmful to the teeth, but the facts seem to be as follows: According to the theory universally accepted, the decay of the teeth, technically called caries, is caused by bacteria, such as are found in every mouth, entering the soft portions of the teeth through defects in the hard outer covering. If acid is present in the mouth, and especially in the interstices of the teeth, it tends to eat into the enamel and thus provide an entrance for the caries-producing bacteria. Ordinarily, saliva is alkaline and protects the teeth against this danger, but when it is in contact with sugar or starch, acid is produced, hence a carbohydrate material lodged upon the teeth may be the indirect cause of caries. Some authorities hold that certain forms of sugar cause the flow of a less alkaline saliva, but this point is not fully established. In general, it is believed that starch is just as dangerous as sugar, and that the form and manner in which the material is eaten is a more important consideration than its exact chemical structure. Soft foods are especially likely to cause trouble, both because bits of them may remain on the teeth where they form "plaques" which are centers of bacterial action so long as they remain, and because they are swallowed without much chewing and thus do not rub the food "plaques" or other deposits from the teeth. Modern specialists consider that the cleansing action of proper mastication is as important for the preservation of the teeth as the regular use of a toothbrush, important as this last is. Any soft carbohydrate food eaten alone is much more likely to leave a deposit on the teeth than if it is eaten in combination with other foods. If candies are eaten by themselves, they are more likely to cause the development of acid in the mouth than if they are taken during a meal. Some physicians advise finishing the meal with acid fruit for the sake of lessening the chances of carbohydrate material clinging to the teeth. While soft foods may possibly cause trouble, the hard ones may also be dangerous, especially to diseased teeth, as the effort to crush them may tend to increase flaws in the enamel. Such things as hard crusty food, hard candies such as lemon drops, stick candy, etc., may be dangerous in this respect, though investigations by G. V. Black[1] on the crushing force of the teeth have proved that sound teeth are capable of crushing much harder substances than these without injury.

EFFECT OF EXERCISE ON THE AMOUNT OF SUGAR WHICH MAY BE EATEN.

The amount of sugar that may be eaten without bad effects depends much on the amount of exercise taken. It has been observed that a man doing hard work in the open air can easily assimilate large quantities of sugar, while the same quantity would cause indigestion if eaten when living indoors and taking little exercise. This is what might be expected, as the active outdoor life means much physical work or exercise, either of which involves much muscular energy. Sugar, as has been pointed out, is a valuable energy-yielding food.

SUGAR IN COOKING, PRESERVING, AND CONFECTIONERY.

Sugar is used in cookery, in the manufacture of confectionery, which is almost entirely sugar, and as an addition to a great variety of foods. It is almost always used with cooked fruit, cakes, pastry, and, in general, food made with eggs and flour, and very rarely with meat dishes in modern cookery, though often added in earlier times, as old recipe books show, to meat pies, which were heavily seasoned with sugar and spice. Mince pie is one of the very few surviving representatives of such foods. Sugar and fat are often cooked together, and many foods, butter-scotch for example, owe their pleasing flavor to this combination. Sugar and suet are often used, as in puddings, but less often now than formerly.

Sugar added in cakes and pastry affects the texture as well as the composition and flavor, as any cook knows. A special form of cookery is the making of preserves, jams, jellies, etc., and in these sugar in thick, heavy solution not only adds to the palatability and character of the flavor, but it also acts as a preservative. On the contrary, thin solutions of sugar alone or with fruit juices, etc., are very readily subject to decomposition by microorganisms. Hence, in order that it may act as a preservative, a solution of sugar must be concentrated.

Without doubt more sugar is used in cookery and in making jams, jellies, and preserves, and in making confectionery (which is a special form of cookery) than in any other way. In general it may be said that for ordinary cakes the proportion of sugar is not usually greater than one part by measure to two parts of flour, and that too much sugar should not be used in making puddings, cakes, etc., since oversweetening, like other forms of overflavoring, is regarded as a mark of unskilled cookery. In the case of canned fruits a common proportion is one part of sugar to two parts of fruit by weight; for preserves, equal parts of sugar and fruit; and for jellies, three-quarters to one part by weight of sugar to one part of juice.

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[1] A work on operative dentistry, Chicago and London, 1908, Vol. I, p. 161.

Detailed recipes for making preserves, jellies, and similar articles are given in earlier bulletins[1] in this series. Directions for making cakes, pies, puddings, and other such dishes in which sugar is an important part can be found in cookbooks and similar publications.

Candy of the better grade is very largely made up of sugar, with the addition of various coloring matters and flavors, nuts, fruit, etc., and sometimes fat, starch, and commercial glucose. The food value of most candies may be expressed by the amount of the sugar contained (72 to 96 per cent), but as regards wholesomeness the other ingredients must be taken into account. The coloring matters used in cheap candies are nearly all compounds of anilin or other coal-tar products, some of which are thought to be harmless. Some of the coloring matters and flavors used, however, have been shown to be harmful. Ordinary caution would suggest that children, at least, be allowed to partake very sparingly of such unknown compounds. Two hundred and fifty samples of cheap candy examined by the Bureau of Chemistry of this department a few years ago were found to be made up largely of commercial glucose with a little sugar and starch. Candies are often exposed to the dust and dirt in stores and booths, taken out of jars and boxes by dirty hands, or weighed in scales of questionable cleanliness. Dangerous microorganisms such as are frequently present in dust may thus lodge on them and be eaten with the candy. Cleanliness in the marketing of this class of goods is just as necessary as in the case of fruits or vegetables, perhaps more so, as the others can be washed if they are to be eaten raw, and candies would not be washed.

Studies recently made in Pennsylvania[2] show that while there has been marked improvement in the quality of cheap candies during the last few years, there is room for still greater improvement in the form of these candies and the method of marketing them. Many are made in the form of whistles, marbles, belts, and necklaces, which the children often play with and which become very dirty before they are eaten. The desirability of having candies wrapped or at least protected from dust and dirt while exposed for sale is evident.

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[1] U. S. Dept. Agr., Farmers' Buls. 203, Canned Fruit, Preserves, and Jellies—Household Methods of Preparation; 359, Canning Vegetables in the Home; and 426, Canning Peaches on the Farm.

[2] Pennsylvania Dept. Agr., Dairy and Food Div. Bul. 216.

The custom of marketing candies wrapped or of packing them in boxes, etc., at the factory is a growing one, particularly with the more expensive sorts, and is certainly a measure which makes for cleanliness. With respect to the candies themselves, manufacturers who realize their responsibility endeavor to insure sanitary conditions in their manufactories. In a number of States the candy factories, like like other food manufactories, are inspected under State auspices.

SUGAR IN FRUITS.

A large number of studies of fruits and fruit products by the California experiment station indicate that the food value of fruits is largely due to the various sugars they contain, the ones most commonly found being cane sugar, grape sugar or dextrose, and fruit sugar or levulose, the last two usually present together in equal quantities, in which case they are collectively known as invert sugar, though sometimes not in equal quantities, in which case they are called reducing sugar.

The stage of growth and the degree of ripeness have a very decided effect on the kind and amount of sugar present in fruits, and it is therefore difficult to give average figures which will fairly represent the quantities present. According to figures published several years ago, invert sugar ranges from about 2 per cent in large early apricots to 15 per cent in grapes and a variety of sweet cherries, while strawberries, gooseberries, raspberries, and apples contain about half the latter quantity. The cane sugar ranges from less than 1 per cent in lemons to 14 per cent in a variety of plums. Ripe bananas were also found to contain a fairly high percentage, namely, 11 per cent.

Dried fruits, like figs, dates, and raisins, which have been concentrated by evaporation, naturally contain much greater proportions of sugar than fresh fruits, the amount of levulose reported being sometimes over 50 per cent. The use of such sweet fruits for sweetening cooked breakfast cereals and other dishes is by no means uncommon. The question of the sugar content of fresh fruits and dried fruits and their value as food has been discussed in earlier publications.[1]

Jams, jellies, and similar products almost always contain added sugar, and hence their nutritive value may be considerable. Home-made jams are often cooked longer than the commercial ones, and therefore may contain a larger proportion of invert sugar. On the other hand, commercial brands are often made with glucose, but the law requires that the fact be stated on the label, along with the proportions of chemical preservatives, etc., if present. (See also p. 12.)

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[1] U. S. Dept. Agr., Farmers' Bul. 293, Use of Fruit as Food; U. S. Dept. Agr., Yearbook 1912, p. 505, Raisins, Figs, and Other Dried Fruits, and Their Uses as Food.

SUGAR IN THE DIETARIES OF CHILDREN.

The amount of sugar to be given children and in what form is a question of much importance. Sugar would seem to be a food especially adapted to children because of their great activity. The relatively small body of the child loses more heat from the skin for every pound of body weight than does the larger person, and children, on this account and because of their active life, require proportionally more heat units in their food than do adults.

Fat, especially fat meat, which could readily supply this need, is often disliked by the child, and his relish for all kinds of sweets has doubtless a physiological basis. It is to be remembered, however, that before the introduction of cane sugar as we now know it countless generations of children had been reared without its help. The digestibility of sugar and sweetened foods for children and their influence on the appetite for other foods must decide to what extent sugar is to replace starch in the dietary and how far it may be safely used as a flavor.

Until a child's stomach is capable of digesting starch the needed carbohydrate is furnished in the sugar of milk, the child a year old who drinks 2 quarts of milk a day taking in this way about 3 ounces of milk sugar. As the stomach becomes able to digest starch the child is less and less dependent on the sugar of milk, replacing it with the carbohydrates of vegetable origin, while the protein and fat found in eggs, meat, breakfast cereals, and bread and butter take the place of those constituents that were at first exclusively furnished in milk. Milk, however, remains throughout childhood a valuable source of all these food principles.

The fact that sugar has a high food value is not the only point to be considered. The child will easily obtain the needed carbohydrates in other forms, and will thrive if its digestion remains sound and its relish for wholesome food unimpaired. For instance, one often hears it said that a certain child does not relish milk. In such cases it might be found that the child's appetite, being sated by sugar in other foods, is no longer attracted by the mild sweetness of fresh milk, delicious as it is to the unspoiled palate. It would be well, perhaps, in this instance to cut down the allowance of sugar in the hope of restoring the taste for so invaluable a food as milk. Many believe that the infant, even in its second year, should not be permitted to taste sweets, in order to prevent perversion of the appetite. Even much later, for the same reason, the introduction of large amounts of sugar into the daily food of children is to be carefully considered. Children do not require a variety of flavors to stimulate the appetite, but the taste is easily perverted and the restoration of a normal appetite is difficult. Those who have studied the food habits of children seem to agree that sugar should from the very first be withheld from the dish that forms the staple food of the child—that is, the mush or porridge of oatmeal or other cereal. This article of diet, eaten only with milk or cream, falls into the same class as bread and milk and forms the simple, wholesome basis of a meal. The sugar given the child is better furnished in the occasional simple pudding, in the lump of sugar, or homemade candy, not that its food value is better utilized, but that the whole diet of the child is thus made more wholesome. In sweet fruits, fully ripened, the child finds sugar in a healthful form, and they should be freely furnished.

COMPARATIVE COST OF SUGAR AS FOOD.

Ten cents' worth of sugar at 6 cents per pound would furnish 2,920 calories of energy. At 6 or 7 cents per pound sugar compares favorably with other foods as a source of energy, although it is more expensive than starch in the form of such cereal foods as wheat flour, corn meal, and oatmeal, which contain 65 to 80 per cent of carbohydrates and, in addition, 10 to 14 per cent of protein, and cost from 2.5 to 4 cents per pound. Judging from the results of many dietary studies, the average cost of sugar in the daily ration is about 2 cents, and, compared with some other common foods, sugar is not an expensive item in the dietary.

GENERAL CONCLUSIONS.

One may say in general that the wholesomeness of sweetened foods and their utilization by the system is largely a question of quantity and concentration. For instance, a simple pudding flavored with sugar rather than heavily sweetened is considered easy of digestion, but when more sugar is used, with the addition of eggs and fat, we have as the result highly concentrated forms of food, which can be eaten with advantage only in moderate quantities and which are entirely unsuited to children and invalids.

It is true that the harvester, lumberman, and others who do hard work in the open air consume great amounts of food containing considerable quantities of sugar, such as pie and doughnuts, and apparently with impunity; but it is equally true that people living an indoor life find that undue amounts of pie, cake, and pudding, with highly sweetened preserved fruit, and sugar in large amounts on cooked cereals, almost always bring indigestion sooner or later.

From a gastronomic point of view it would seem also that in the American cuisine sugar is used with too many kinds of food, with a consequent loss of variety and piquancy of flavor in the different dishes. The nutty flavor of grains and the natural taste of mild fruits are very often concealed by the addition of large quantities of sugar.

In the diet of the undernourished larger amounts of sugar would doubtless help to supply adequate nutrition. This point is often urged by European hygienists. In the food of the well-to-do it is often the case, however, that starch is not diminished in proportion as sugar is added. That sugar, on account of its agreeable flavor, furnishes a temptation to take more carbohydrate food than the system needs can not be denied. The vigor of digestion and muscular activity in each particular case would seem to suggest the limit. A lump of sugar represents about as much nutriment as an ounce of potato, but, while the potato will be eaten only because hunger prompts, the sugar, because of its taste, may be taken when the appetite has been fully satisfied.

Sugar is a useful and valuable food. It must, however, be remembered that it is a concentrated food, and therefore should be eaten in moderate quantities. Further, like other concentrated foods, sugar seems best fitted for assimilation by the body when supplied with other materials which dilute it or give it the necessary bulk.

Persons of active habits and good digestion will add sugar to their food almost at pleasure without inconvenience, while those of sedentary life, of delicate digestion, or with a tendency to corpulency would do better to use sugar very moderately. It is generally assumed that 4 or 5 ounces of sugar per day is as much as it is well for the average adult to eat under ordinary conditions.

(A list giving the titles of all Farmers' Bulletins available for distribution will be sent free upon application to a Member of Congress or the Secretary of Agriculture.)

A1.9: 536

Issued May 1, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 536.

STOCK POISONING DUE TO SCARCITY OF FOOD.

UNIVERSITY OF VIRGINIA LIBRARY 1819

BY

C. DWIGHT MARSH,

Physiologist, Drug-Plant, Poisonous-Plant, Physiological, and Fermentation Investigations, Bureau of Plant Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., March 18, 1913.

SIR: I have the honor to transmit herewith a paper entitled "Stock Poisoning Due to Scarcity of Food," by Dr. C. D. Marsh, which has been submitted by Dr. R. H. True, Physiologist in Charge of Drug-Plant, Poisonous-Plant, Physiological, and Fermentation Investigations, and recommend that this be published as a Farmers' Bulletin.

Respectfully,

WM. A. TAYLOR,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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B. P. I.—862.

STOCK POISONING DUE TO SCARCITY OF FOOD.

INTRODUCTION.

It is generally recognized that the heaviest losses of live stock from poisonous plants occur in seasons when feed is short, but the intimate relation between such losses and the food supply does not seem to be appreciated at its full value. If it were understood and acted upon intelligently there would be much less complaint of harm done by poisonous plants.

POISONING PROBABLE ONLY WHEN FEED IS SCARCE.

Stock seldom eat poisonous plants when good feed is available. This is, in general, true even for the loco weeds, although it is well known that some animals have a loco habit and will eat these weeds in preference to anything else. This habit, however, is usually acquired during a season of short feed, when the loco weeds are the most attractive form of vegetation. If the stock can be prevented from acquiring the habit during this period of scarcity, there will be very few locoed animals.

Larkspur poisoning is most likely to occur either during the season of short feed or on an overgrazed area; in either case the larkspur is the most conspicuous form of vegetation to attract the animals and is eaten in lieu of anything better.

The roots of water hemlock (Cicuta) are picked up when there is little else to eat and with disastrous results.

Successive bands of sheep are driven over the same trail until everything suitable for food disappears, and then there follow cases of poisoning from wild cherry. On some trails there is an almost continuous hedge of wild cherry, and the leaves are eaten as high as the sheep can reach. We may assume that in such cases the first to pass over the trail are not poisoned, because there is something else to eat, and the last are not poisoned, because at that time even the poisonous plants have been consumed.

Sheep are sometimes bedded in the same place for several successive days. Under such circumstances everything near the bedding ground is eaten, and if there are any poisonous plants some of the sheep are pretty sure to get them. One of the heavy losses of the season of 1912 was brought about in this way. For five nights a band was bedded in the same place, with a consequent loss of 200 head. A band in the same neighborhood wandering without a herder suffered no loss.

If sheep are poisoned by milkweeds, and the evidence seems to be fairly conclusive that they are, it is only when there is little else to eat, for sheep do not eat milkweeds under normal conditions.

In the Carolinas, cattle are poisoned by "stagger grass" (*Amianthium muscaetoxicum*) only in the spring. This lily then grows luxuriantly, at a time when there is little or no grass, and the cattle eat it in default of something better.

CONCLUSIONS.

The plants here referred to have been mentioned only as definite examples of a general truth. Stock seldom eat poisonous plants by choice, but only when induced or compelled by the scarcity of other food. It, perhaps, can not be too strongly impressed upon those using the stock ranges that their losses may be very largely reduced if they will recognize this fact and take a few obvious precautions.

(1) Stock should not be turned out upon the range where there is little to eat except poisonous plants. This is especially dangerous when the stock have been on dry feed.

(2) In a region where certain areas are definitely known to be infested with poisonous plants, stock should be kept away. This is especially necessary when the general range is short, either because grass has not started to grow or because it has been overgrazed. When the range is well covered with good grasses, herding away from poisonous areas is ordinarily unnecessary.

(3) When stock are trailed from one place to another, they should, so far as possible, be driven through a country with plenty of good feed. If it is necessary to drive them through a locality supposed to be infested with poisonous plants, care should be taken to see that the stock are not hungry when going through this region. It is much better to make such a drive in the afternoon rather than in the morning. Special precautions must be taken when it is necessary to pass over a trail that has been used by many others, for all good feed will have disappeared and the stock will eat whatever is left. Sheep should not be bedded for several successive nights in the same place.

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Issued May 28, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 537.

HOW TO GROW AN ACRE OF CORN.

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BY

C. P. HARTLEY,
Physiologist in Charge of Corn Investigations.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., March 27, 1913.

SIR: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a manuscript entitled "How to Grow an Acre of Corn," by Mr. C. P. Hartley, Physiologist in Charge of Corn Investigations.

Respectfully,

WM. A. TAYLOR,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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B. P. I.—871.

HOW TO GROW AN ACRE OF CORN.[1]

INTRODUCTION.

For no 10-year period has the corn yield of the United States exceeded 28 bushels per acre. No State has averaged for any year over 54 bushels per acre, yet in practically every section of the United States yields of more than 100 bushels have been produced. As States and as a Nation twice as much land is being used and much more labor is being performed in producing the corn crop than is necessary.

The possibility of doubling our acre yield of corn is so certain and its accomplishment of such tremendous importance that school, State, national, and independent organizations of corn clubs and associations of corn breeders and corn growers are helping in a way that will lead to success. Such clubs and associations are especially fitted for this most important work, for they combine the yearly experience of many and can continue their records indefinitely, each year profiting by past experiences.

In the following pages some fundamental requirements for large and profitable corn yields on 1 acre are given for the general guidance of boys either as individuals or as members of clubs and associations. Exceptional and local conditions are not here discussed. General and fundamental requirements of the crop as gained by experiences in many parts of the United States are given as a foundation upon which to utilize and apply local experience and instructions from those possessing such experience.

WHAT KIND OF CORN TO GROW.

Grow the kind that is likely to prove most profitable.

If near a good market for roasting ears or a canning factory sweet corn may prove most profitable, or under certain conditions pop corn might pay best. (Figs. 1 and 2.)

For some sections varieties of the dent-corn group are too soft to resist decay and varieties of the flint-corn group are more profitable. (Figs. 3 and 4.)

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[1] Copies of any of the following Farmers' Bulletins upon the subject of corn will be sent free of charge upon application to a Senator or Representative in Congress or to the Secretary of Agriculture: 81, Corn culture in the South; 229, The production of good seed corn; 253, The germination of seed corn; 272, A successful hog and seed-corn farm; 298, Food value of corn and corn products; 303, Corn-harvesting machinery; 313, Harvesting and storing corn; 400, A more profitable corn-planting method; 409, School lessons on corn; 414, Corn cultivation; and 415, Seed corn.

In practically every corn-growing community there is a strong demand every spring for first-class seed corn.

The acre can be made highly profitable if devoted to the growing of seed corn of the most productive variety for the neighborhood.

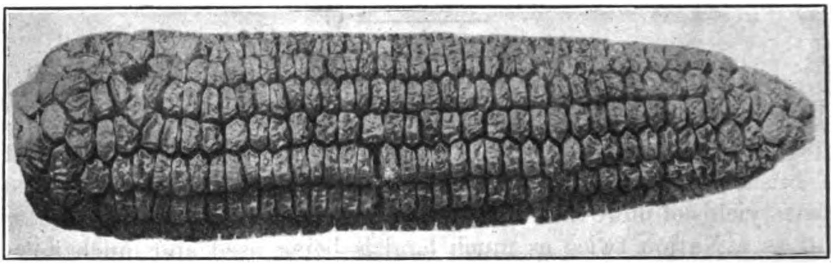

FIG. 1.—A good seed ear of the sweet-corn group and of the variety known as Early Evergreen.

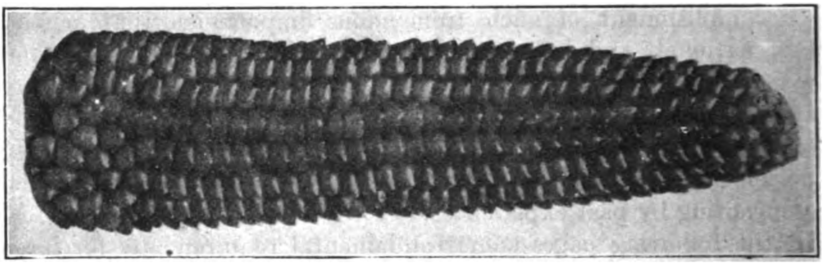

FIG. 2.—A good seed ear of the pop-corn group and of the variety known as White Rice.

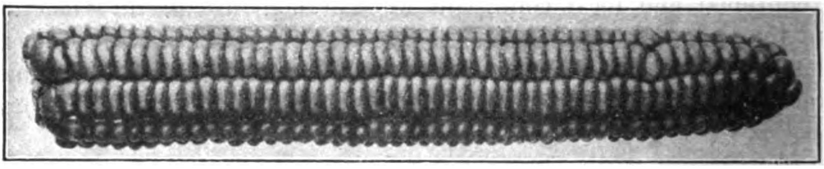

FIG. 3.—A good seed ear of the flint-corn group and of the variety known as Ninety-Day Yellow Flint. Flint varieties do not absorb moisture and spoil as readily as dent varieties.

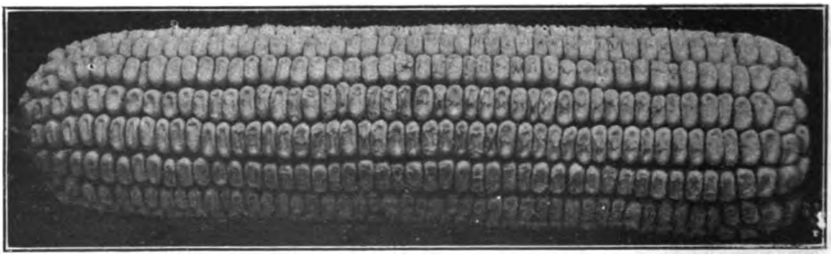

FIG. 4.—A good seed ear of the dent-corn group and of the variety known as Woodburn White Dent. For a field view of this corn see figure 6.

If the crop is sold as commercial corn, 50 or 75 cents a bushel will be received, but by selecting at the proper time all that is suitable for seed and giving it good care till planting time $2 or $3 a bushel can be obtained.

The variety that has generally produced the most good, sound grain in the neighborhood is the variety to plant, and it can be greatly improved by careful seed selection. It is also the corn that will be most in demand for seed throughout the neighborhood.

If corn throughout the county generally fails to ripen properly, take up work with an earlier maturing variety. (Fig. 5.)

If the corn generally grows too tall (fig. 6), take up work with seed from stalks that do not grow too tall.

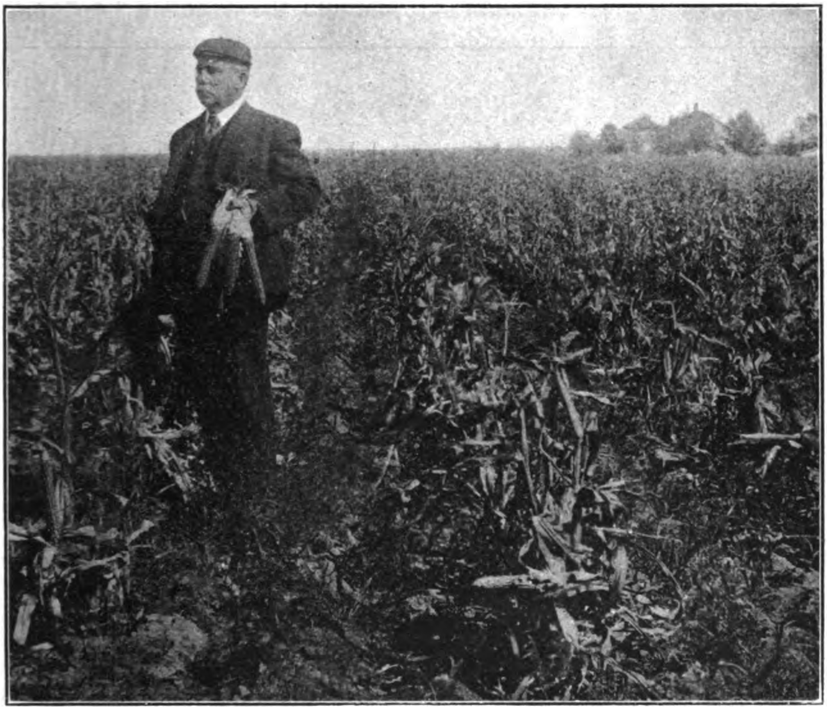

FIG. 5.—A field of Gehu Yellow Flint corn near Bismarck, N. Dak. A successful crop necessitates that the variety be well adapted to the climatic and soil conditions under which it is grown.

If the most productive varieties of the neighborhood are prolific varieties (fig. 7), take up work with the one that seems to have been giving most general satisfaction.

If the most productive varieties of the neighborhood are 1-eared varieties, take up work with the one that seems to have been giving most general satisfaction.

WHEN TO TAKE UP CORN-IMPROVEMENT WORK.

Just as soon as you reach a determination to persevere until successful you should begin corn-improvement work.

Each community needs an experienced and conscientious corn breeder.

By starting while young and keeping at it, boys have splendid opportunities to produce better varieties than have ever been produced.

The Office of Corn Investigations of the United States Department of Agriculture wants to help a boy in each county who has produced the best corn crop for a number of years to become an efficient, conscientious seed-corn grower for his county.

Some feature or other of the work needs attention at all seasons of the year.

These features must be attended to at the proper time, as success is not likely to be won by spasmodic attempts. It is usually won by perseverance, which causes each operation to be accomplished at the proper time and in the best manner.

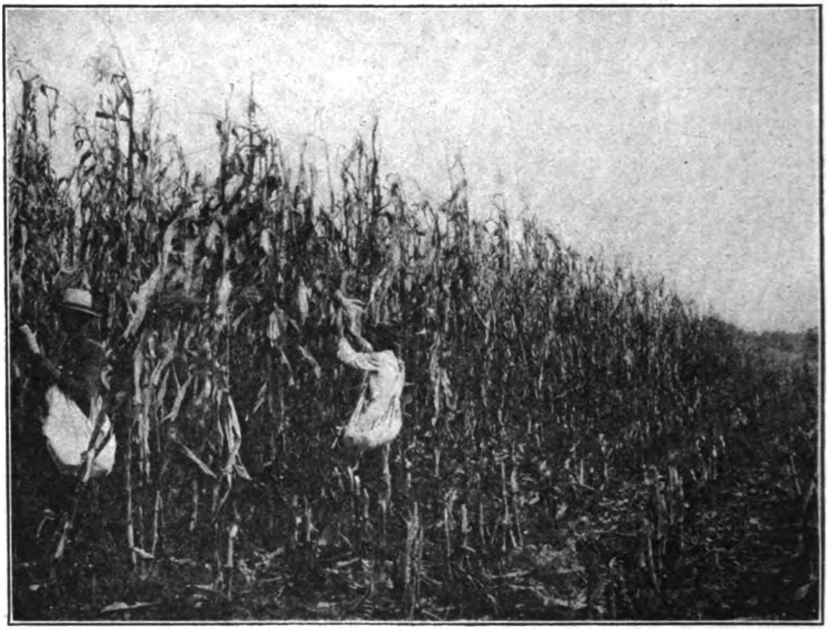

FIG. 6.—A field of Woodburn White Dent corn in southern Ohio, photographed in 1904, since which time by careful selection the height of stalks and ears has been advantageously reduced and the productivity increased. Last year 881 acres averaged 83 bushels of dry shelled corn to the acre.

At planting time hopes of success are usually brightest, but the exercise of ability at seed-selecting time, at plowing time, and at many other times is necessary.

SELECTING SEED FOR THE ACRE.

Select seed ears in the field from the very best stalks and as soon as the ears are ripe. (See "Drying and caring for seed corn," p. 19.)

Select at least 100 ears; 200 are much better, and it is still better if some ears of the same variety be selected from a neighboring field or farm.

The acre is to be a seed patch, and the improvement of a variety of corn should not begin with a small number of ears, as close breeding is likely to gradually reduce productiveness.

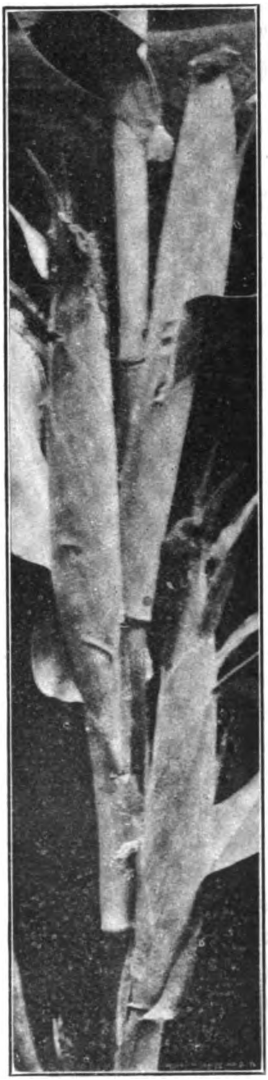

FIG. 7.—A stalk of corn of a prolific variety. Varieties that bear two or more ears to the stalk are known as prolific varieties. In general the size of ear decreases as the number of ears to the stalk increases.

PREPARING THE SEED FOR PLANTING.

Such work as sorting, testing germinating qualities, shelling, etc., should be done in the early spring before field work demands attention.

The best time to grade seed corn is before shelling.

Only heavy, solid ears should be used for seed, and the ears chosen should contain kernels of a good uniform length, width, and thickness.

Ears containing kernels of various sizes and shapes should be discarded.

The ears can be numbered by sticking a pin through a piece of paper into the end of the cob, and 10 kernels taken from each ear can then be tested to determine whether they will grow. If weak or dead kernels are found, the ears from which they were taken should be discarded. See Farmers' Bulletins 229 and 253.

Before shelling, all small and poorly developed kernels should be removed from the ears, for they will produce weak and barren stalks.

If the seed is to be planted by means of a corn planter, the large, irregular kernels from the butts of the ears should also be discarded before the ears are shelled.

The proper way to shell seed corn is by hand, shelling one ear at a time into a coarse-meshed sieve. This enables the kernels and cob from each ear to be closely inspected and all kernels to be easily rejected if any defect is found. The sieve facilitates the separation of the chaff and other small particles from the seed.

SELECTING AN ACRE FOR CORN.

It is better to have the seed acre adjacent to or a part of a larger field of the same variety of corn.

An isolated acre of corn is very likely to meet with injury from live stock, squirrels, crows, chinch bugs, or grasshoppers at some time during the season.

The soil should be fertile and loose to a great depth. A good corn crop can not be produced on hard, depleted soil.

A highly profitable corn crop depends very largely upon the selection of a fertile, well-drained location.

The acre should be uniform, so that all parts will be in proper condition for cultivation at the same time.

The nature of the season can not be foretold; therefore it is impossible to predict whether high land or low land will produce better, but as corn makes a tall, thrifty growth, requiring much moisture, low land usually being better supplied with moisture and fertility is likely, if well drained, to produce better than high land.

Choose land that usually produces heavy crops and, if possible, land that has recently produced vigorous crops of clover, cowpeas, alfalfa, vetch, or some other legume. A heavy growth of large, vigorous horseweeds, cocklebur, or other rank-growing weeds indicates a good corn soil.

Alfalfa, clover, and similar plants send their roots to great depths and are the best crops to turn under for the purpose of growing a very large corn crop. Their culture is the best and most economical way of subsoiling land. The deep-growing roots loosen the subsoil and keep it porous long after the crop is turned under. Without sufficient rainfall unusually poor corn crops are obtained on alfalfa sod, the soil moisture having been exhausted to a great depth by the roots of the alfalfa.

Outer rows of corn are usually broken down in cultivating and are usually injured more by chinch bugs or grasshoppers from adjacent fields or by hot winds. Therefore, more than an acre should be planted, so that at least four guard rows of corn may surround the test acre.

FERTILIZING THE ACRE.

A liberal supply of soil moisture is indispensable to a good corn yield.

Well-decomposed manure is the surest fertilizer for producing a large corn crop.

Failure is quite sure to follow an attempt to grow a large corn crop on hard or depleted soil unless its hard or depleted condition is overcome by a liberal application of manure.

Barnyard manure that is well decomposed and moist can safely be applied abundantly, 20 or 40 tons to the acre.

Where rainfall is deficient, manure containing stalks or undecomposed straw may reduce the corn yield by admitting too much air into the soil and facilitating the escape of soil moisture.

Manure and decomposed vegetable matter greatly increase the water-absorbing and water-holding capacity of a soil.

Where heavy applications are made, the manure should be well mixed with the soil, and preferably this should be done several months previous to planting the corn.

Manure should be applied before its soluble parts have leached away by exposure to rain.

It is unwise to attempt to grow a profitable corn crop on hard, depleted soil by a heavy application of commercial fertilizers without improving the physical condition of the soil.

If local tests have demonstrated that a soil responds with increased yields to the application of a particular element, that element should be liberally applied.

Many soils contain an abundance of potassium, but some soils, notably some peaty soils, are so deficient in this element that they yield very unprofitable corn crops without its application and very profitable corn crops when potassium is supplied.

Some heavy clay soils and sandy soils are often improved by an application of lime, and in many localities ground phosphate rock can be profitably used in growing corn. The lime is applied to best advantage for the clover or alfalfa crop. The ground phosphate rock is best applied by composting it with manure.

Large corn crops have been grown by heavy applications of commercial fertilizers containing nitrogen, phosphorus, and potassium, but on many soils the application of all these elements is unnecessary, and the application of those not needed increases the cost of production and does not increase the yield. Nitrogen, the most expensive element of commercial fertilizers, is taken from the air and stored in the soil by the growing of legumes.

Commercial fertilizers should be applied broadcast. The corn roots ramify throughout the soil and utilize fertilizers so applied to better advantage than when they are applied directly in the row or hill.

If 300 pounds or more per acre of commercial fertilizers be placed in direct contact with the kernels, they are liable to be killed or so injured that the yield may be reduced.

PREPARATION OF THE SEED BED.

Land is plowed in order to loosen it and enable water to enter in greater quantity, be absorbed to greater depth, and remain longer in the soil.

A deep seed bed well supplied with soil moisture and well drained makes a big corn yield possible whether the summer proves "too dry" or "too wet."

If not well plowed, some lands are so impervious that during several weeks of rainy weather they remain dry below a depth of 5 or 10 inches.

In many localities it is best to plow in the fall or several months before planting, in order to enable the soil to store a sufficient amount of water to produce a corn crop. In some localities it is necessary to grow rye or some other crop on fall-plowed land to prevent erosion.

Heavy cover crops should be turned under in the fall, winter, or very early spring in order to give time for decay before corn is planted on the land.

Land should never be plowed when too wet to pulverize finely. In the fall, plowing may be done even when the ground is too dry, as winter rains and freezing will pulverize the clods.

If plowing is done in the spring shortly before planting time, it is necessary that the soil be in proper condition to pulverize readily. (Fig. 8.)

Spring-plowed land should be harrowed the same day it is plowed.

Disking land in the spring before plowing is a great advantage. It retains moisture and keeps the land longer in a good plowing condition. It also pulverizes the surface portion of the furrow slice before it is turned under out of reach of the harrow.

When the soil is loose to a sufficient depth, corn roots penetrate in abundance to a depth of 3 or 4 feet.

The growing of clover and deep-rooted plants is profitably practiced with most soils, and subsoiling is profitably practiced with some soils to increase their water-absorbing capacity and to enable the corn roots to use the soil to greater depths.

By growing deep-rooted crops or by some other means, the soil should be loosened to a great depth. As the crop on an acre is limited to 43,560 square feet of surface, it should be enabled to use the acre to a great depth. In compact soils plowed but 6 inches deep and cultivated 3 inches deep there remain but 3 inches of loose, plowed soil in which the corn roots can feed unmolested by summer cultivation, but if plowed 10 inches deep and similarly cultivated there remains more than twice as much loose, unmolested soil for the corn roots.

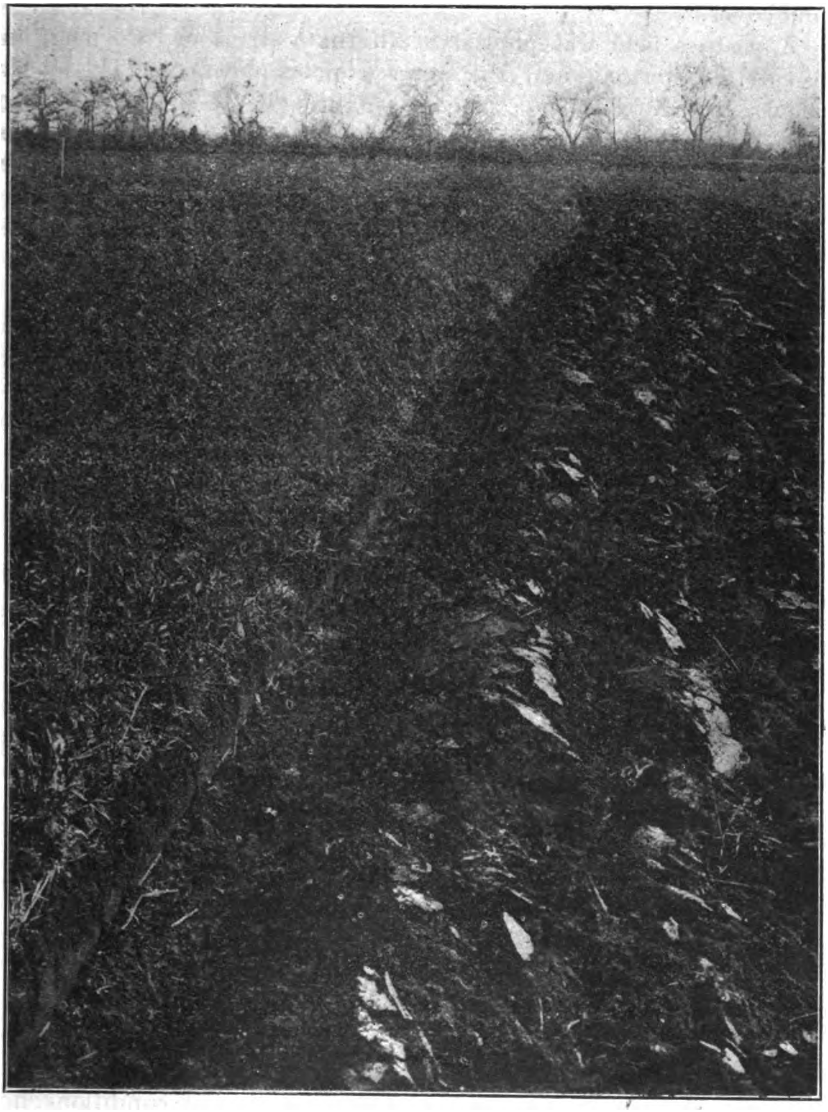

FIG. 8.—A field having soil in good condition for plowing, but the plowing shown is not deep enough for corn.

There are good disk plows, there are good walking moldboard plows, and there are good sulky moldboard plows.

Poor plowing can be done with a good plow.

Use large plows and plenty of power.

On many heavy clay soils the yield of corn per acre depends largely upon the thoroughness of the plowing.

Loosen all the land and leave no large air spaces. Do not "cut and cover."

A pasture field was plowed in alternate strips by two men, one a careful plowman and the other a poor plowman. The poorly plowed strips showed poorer corn all through the summer and produced 20 bushels less corn to the acre than the well-plowed strips. The careless plowman allowed the plow to "cut and cover" in places, leaving hard spots where the plow did not loosen the land and large air spaces where the overturned sod buckled and did not come in contact with the subsoil. Hills of corn growing on hard spots or over large air spaces usually produce poorly.

Where a heavy growth of clover or weeds or a heavy application of manure was plowed under in the fall, the land should be given, just previous to planting, a cultivation as deep as it was plowed. This deep cultivation mixes the humus throughout the soil and is of more value than any other cultivation the corn crop can be given. It is economical, because wider cultivators and more horses can be employed than is possible after the corn is planted.

PLANTING.

There are many questions concerning implements, methods, distance between rows, thickness of planting, etc., that should be definitely settled before planting time. These questions are governed to a large degree by local conditions.

A distance of 3.3 feet between corn rows is suggested for the majority of cases. Some 2-row planters are more easily adjusted to 3 feet 4 inches, which is very satisfactory.

More space is required for tall-growing than for smaller varieties.

It is never advisable to use seed that germinates poorly, and with first-class seed it is well to drop twice as many kernels as the number of stalks desired.

In planting, this familiar saying should be followed: "One for the blackbird, one for the crow, one for the cutworm, and three for to grow."

On poor land and also in very dry sections larger grain yields can be secured with a thin stand of stalks. Under such conditions, however, some other crop can usually be grown more profitably than corn, for corn requires much moisture and fertility.

In sections where the annual rainfall is less than 25 inches a thin stand of stalks is preferable unless moisture is supplied from some other source than rain.

Where soil moisture is likely to be deficient during the silking period, a stalk for each 20 inches of row (the rows being 3.3 feet apart) is sufficient and will make possible a yield of 113 bushels per acre if the stalks average a pound of grain each.

With an abundance of fertility and rainfall 12,000 or more stalks to the acre are necessary for obtaining record yields.

With an abundance of fertility and soil moisture throughout the silking period, a stalk for each 12 inches of row is advisable and will make possible a yield of 188 bushels per acre, the stalks averaging 1 pound of grain each.

Drilled corn, if kept equally well cultivated and free from weeds, will usually produce better than hill-planted corn. The stalks develop better and yield better when separated from each other by several inches than when crowded closely together in hills.

If the acre is planted in hills by hand the kernels should be separated in each hill by several inches. This tends to increase the yield and makes it easier to thin without loosening or injuring the remaining stalks.

In the proper kind of seed bed the kernels should be covered 1 inch deep. They should come in contact with moist soil. They can not germinate in dry soil and are liable to injury before rain occurs.

A successful planting, a satisfactory stand of plants, and a profitable yield are largely assured by getting the seed bed in a perfect condition for very early planting and then waiting to plant until the soil is warm and moist.

The best possible yield necessitates the proper number of stalks evenly distributed. But this alone is not sufficient. Quality of stalks is as necessary as quantity of stalks. The proper number of stalks can be obtained by heavy planting of poor seed, but stalks from such seed will not produce well. The quality of a stalk is determined by the seed and the conditions for good production with which it is provided.

The secret of a prize-winning corn crop consists in having the proper stand of stalks, each one of which yields well. This can be best accomplished by the heavy planting of good seed and thinning out the poorest plants.

Replanting seldom increases the grain yield.

Cultivating up the first planting and planting the entire acre the second time is better than replanting a poor stand.

COMBATING CUTWORMS.

In many sections it is seldom possible to plant corn at the proper season without having a large percentage of the young plants destroyed by cutworms.

Fall plowing and late spring planting are methods successfully used to combat cutworms.

A persevering boy can prevent his acre from being seriously injured by cutworms by placing upon each corn hill, immediately after planting, and later on at intervals, lumps of poisoned bait, made by mixing about 50 pounds of wheat bran with a pound of Paris green [1] and enough of the cheapest grade of molasses to make a stiff dough. Many of the worms eat this poisoned bait and die before the corn comes up, but this method of treatment has also proved quite effective even after the plants are well grown. Corn meal may be substituted for the wheat bran in the mixture when the latter is not available.

THINNING.

For highly profitable crops, heavy planting and thinning are advisable, though not always practicable in extensive planting. It is one means a boy has of producing a record-breaking acre of corn.

Thinning should be performed as soon as the stalks are too hard for cutworms to cut off and before they are a foot tall.

A flattened broomstick or a similar stick to which is fastened a flattened piece of iron, like a 2-inch chisel, is of great assistance in thinning, as it is necessary to remove the stalks below the surface of the ground in order to prevent further growth.

Slightly more stalks than a perfect stand should be retained, so that injured, diseased, or feeble stalks can be removed later without reducing the stand below that required for the best grain yield. Such stalks should be considered as weeds and removed as soon as their inferiority is evident.

CULTIVATION.

To produce a maximum yield, corn roots require warmth, a certain amount of air, and considerable moisture.

Corn is cultivated in order to supply these requirements.

Too much water and too little air in the soil as surely prevent healthy growth as too much air and too little water.

Air is deficient in saturated soils, and on such soils corn plants become yellow and unproductive.

Good cultivation at the proper time admits air, lessens the ascent of water from the subsoil, causes the soil to become warmer, and stimulates a better growth.

Weeds should be killed as soon as they begin to grow, but the primary reason for cultivating is to maintain the proper proportion of air and moisture in the soil.

Some successful corn growers, some who have averaged 100 bushels of dry shelled corn to the acre on hundreds of acres, believe the best single cultivation they can give their corn is a cultivation 8 or 10 inches deep given just before planting.

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[1] Paris green is a poison and should not be placed where children or domestic animals can get it.

If prolonged and heavy rains pack the soil to a great depth, a deep cultivation can sometimes be given to advantage while the corn is less than a foot tall.

Soon after the plants become a foot tall their roots reach across the spaces between rows and cultivation should not be deeper than 2 inches. A deeper cultivation is likely to reduce the yield.

A shallow cultivation should be given as soon after every heavy rain as the land becomes in good workable condition. The cultivation should be given with such implements and in such a manner as to leave the soil in a fine, loose, smooth condition. (Fig. 9.)

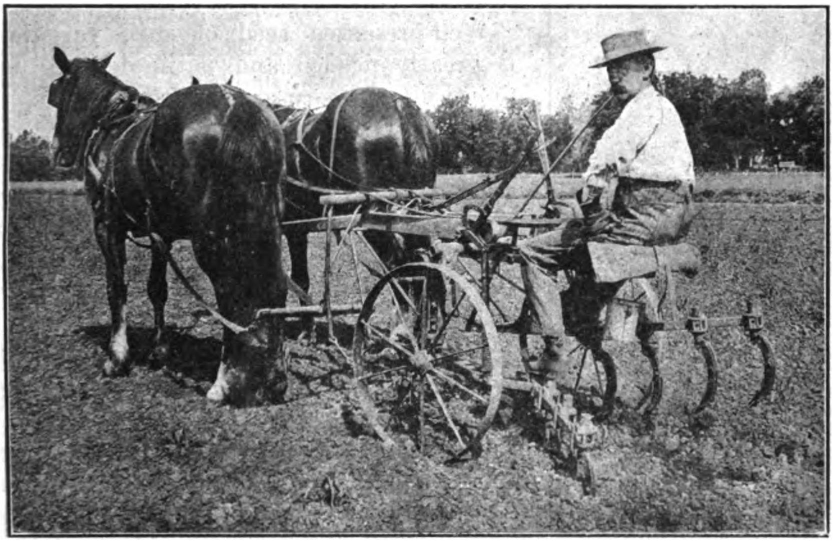

FIG. 9.—A corn cultivator. The kind of cultivator and its proper equipment with sweeps or shovels is governed by the nature of the soil and the object to be accomplished.

It is never safe to allow the soil surface to become hard and too dry to cultivate to the best advantage. Continued dry weather with the soil in this condition is certain to reduce the yield materially, and cultivating such soil results in still greater injury.

Until the silking period the soil surface should be kept in a fine, loose condition, so that in walking on it when dry it is felt to give under the feet and distinct footprints are made.

Shallow cultivations given even as late as silking time are often as valuable as earlier cultivations.

Weeds growing in the corn at silking time reduce yields very materially, as has been conclusively proved by experiments conducted by the Office of Corn Investigations.

Under some conditions six or eight cultivations are advisable, while under other conditions three cultivations may be sufficient to keep the soil in proper condition and would therefore prove more profitable than a greater number.

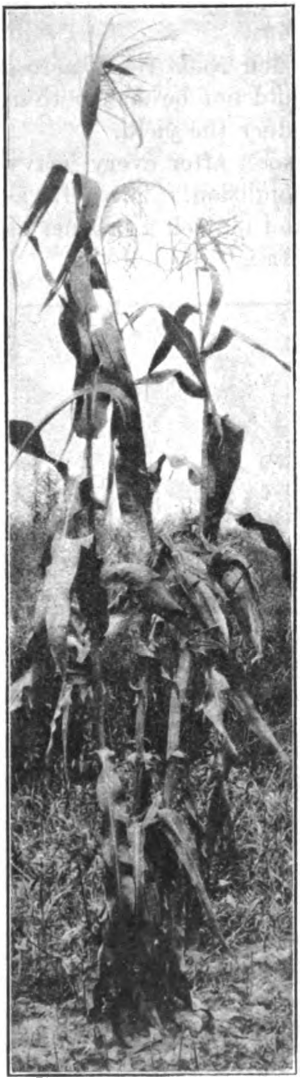

FIG. 10.—Good corn plants from which to select seed. Ears early pendent do not take water and spoil as badly as erect ears.

SELECTING SEED FROM THE ACRE.

It is reasonable to assume that a variety that makes the best yields in a county is adapted to the locality. This is especially true if the same variety produces best for several years.

Well-preserved seed of such varieties is greatly needed and is in demand in practically all corn-growing counties.

It is also fair to assume that seed from a high-yielding acre, if well cared for during the winter, will under similar conditions give equally good yields on many other acres in the neighborhood, and that with better care even greater yields may be obtained.

All good seed ears should be gathered as soon as ripe and before any freezing has occurred.

Go through the acre with a picking bag on the shoulder and gather the ears from the best stalks. By walking between two corn rows the good high-yielding plants in the two rows can be readily found.

The kind of plant from which seed should be taken is one that produces much better without any apparent reason than plants surrounding it. Plants with an unusual amount of space or an unusually fertile location may produce better than surrounding plants without possessing any greater inherent producing power and therefore would be of no special value as plants from which to select seed.

In the Central and Southern States, where there is a tendency for stalks to grow too tall, short thick stalks producing pendent ears at or below their middle point are good stalks. (Fig. 10.) From local varieties low-growing strains can be bred by selecting seed each year from high-yielding but low-growing stalks.

Where exceedingly early-maturing varieties are necessary (see fig. 5), seed should be taken from stalks that produced their ears high enough to keep the ears from touching the ground when they become pendent.

Suckers are undesirable and can be gradually eliminated by taking seed only from stalks that produce no suckers.

In prolific varieties, i. e., varieties bearing two or more ears per stalk, the various ears of a stalk are of equal value for seed.

When an unusually high-yielding and well-proportioned plant is found (fig. 11), the ear or ears should be cut with some of the husk attached, so that such ears can later be distinguished and used in planting the seed acre the next year.

The seed acre of one year must not supply the entire quantity of seed for the seed acre the next year. A continuation of such a practice would tend to reduce the productivity of the variety because of close breeding.

To avoid close breeding, some ears from unusually good plants from other fields of the same variety should be planted each year in the seed acre.

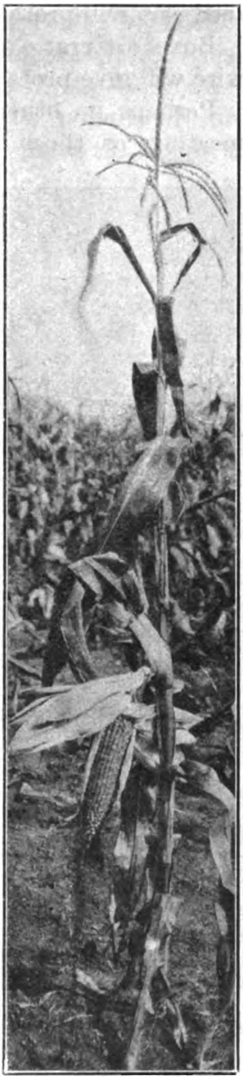

FIG. 11.—A productive and well-proportioned corn plant of a 1-eared variety.

DRYING AND CARING FOR SEED CORN.

Immediately after gathering, the seed ears should be placed to dry in a position where they will not touch each other and where there is a good circulation of air.

Binder twine (fig. 12) or racks made from electrically welded wire fencing (see Farmers' Bulletin 415) are satisfactory means of suspending seed ears to dry.

In many Southern States it is not desirable to leave the ears on the racks all winter, as they are likely to be injured by the grain moth.

When the seed becomes as dry as old corn, it can be taken from the racks, weighed, and stored where neither moisture, moths, nor mice can injure it.

Upon care in this particular depends in a large measure the success of the next year's crop. Poor care has reduced and will reduce the yielding power of seed by 18 bushels per acre without perceptibly injuring its germination.

An upstairs room or an attic usually offers good protection from moisture.

A pound of naphthalene or moth balls stored with each bushel of seed ears will protect it from grain moths and do it no injury.

Boxes or crates completely covered with fly screening or woven wire will give protection from mice and rats.

Perhaps no other regrets are so often heard at boys' corn-club meetings as those regarding the destruction of their seed corn by mice and rats.

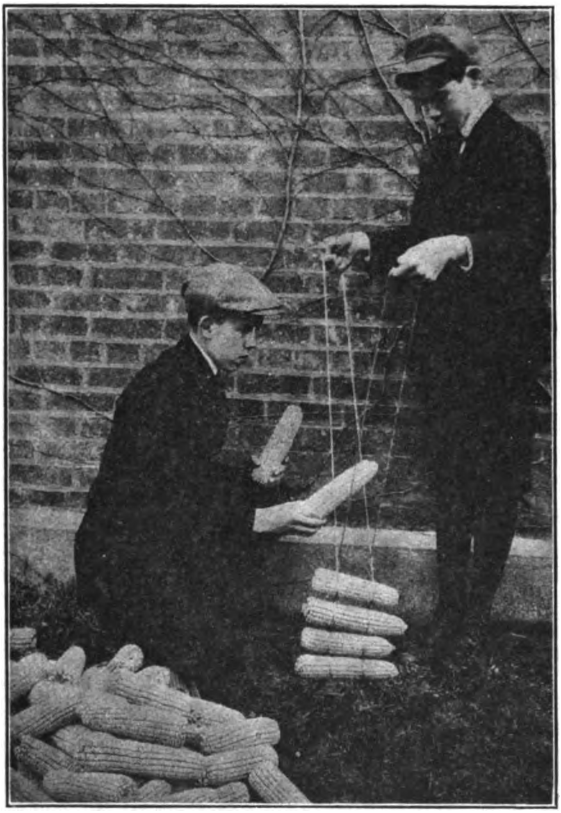

FIG. 12.—Boys using binder twine to suspend ears of corn to dry. By this means two boys can quickly suspend the seed ears in a well-ventilated place.

If seed corn be placed where it is merely supposed that mice or rats can not injure it, the owner is likely to meet disappointment.

There are so many unavoidable things that may cause poor yields that it becomes necessary to insure success in every way possible. The only way to insure the seed supply is to place it where it can not be injured by anything.

DETERMINING THE YIELD.

A record of a big yield to be of value must be honestly and accurately determined according to standard methods of measurement. It is easy to weigh the corn when it is full of water and to measure a smaller area than that which produced the crop, but to do so makes the weighing and measuring a mockery and the record of no value.

Green, sappy ears may weigh twice as much as when dry.

A plat consisting of four corn rows 4,400 feet long and 3.3 feet apart occupies 1 acre if measured from one outside row to the other, but by correct measurement it occupies 1⅓ acres of land.

The number of rows must be multiplied by the average width between rows and this product multiplied by the full length of the plat to obtain the true area from which the corn received benefit.

To make the records of value and have them comparable from year to year it is necessary to consider the moisture in the corn when harvested and weighed. To accomplish this, 100 pounds of ears should be weighed when harvested, put in an airy place till as dry as old corn, and then weighed again and shelled. The weight of shelled corn is the percentage of dry shelled corn, and multiplying the total pounds harvested by this percentage gives the yield in pounds of dry shelled corn.

If the acre was harvested directly after the seed was selected, the harvest weights of all can be reduced to pounds of dry shelled grain by the one calculation. But if the seed was selected while in a sappier condition, a similar process is necessary to determine the pounds of dry shelled grain taken from the acre for seed.

CONCLUSION.

The praiseworthy and highly beneficial cooperative corn-improvement work in progress throughout the United States is making it more urgent that records be kept and that they be kept in definite and comparable terms.

Dry shelled corn per acre is the most definite and generally accepted way of recording corn yields. Old corn, or corn containing approximately 12 per cent of moisture, is considered dry corn. Fifty-six pounds of shelled corn constitute a bushel.

True records will point the way to further improvement. Knowledge of the requirements of the corn plant and of the best practicable means of supplying such requirements is of great and general value to the people of the United States. Our weakest defense is our vast acreage of poor corn, the culture of which is impoverishing farms and farmers.

The possibility of doubling the acre yield of corn has been demonstrated in many and remote sections of the United States. A persistent loyal adherence of all corn-improvement workers to the motto "Fewer acres and more corn to the acre" is certain to gradually raise the average yield of county, State, and Nation.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 538.

SITES, SOILS, AND VARIETIES FOR CITRUS GROVES IN THE GULF STATES.

BY

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Director of the Agricultural Experiment Station of Florida.

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1913.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., March 27, 1913.

Sir: Many requests are received at the Department of Agriculture for information on the methods employed in growing oranges and other citrus fruits in Florida and the other Gulf States, and it is important that the department be able to supply the desired information as fully as possible. In order to furnish this information in concise form, Prof. P. H. Rolfs, Director of the Agricultural Experiment Station of Florida, has revised Farmers' Bulletin 238, entitled "Citrus Fruit Growing in the Gulf States," and has divided the material contained in that publication into three parts, of which this paper is the first, as follows: (1) "Sites, Soils, and Varieties for Citrus Groves in the Gulf States," (2) "Propagation of Citrus Trees in the Gulf States," and (3) "Culture, Fertilization, and Frost Protection of Citrus Groves in the Gulf States." In this form the information will be more available for distribution in the territory directly concerned and will be of more service, it is believed, to prospective fruit growers and to planters already engaged in this industry. I have the honor to recommend that the paper be published as a Farmers' Bulletin.

Respectfully,

William A. Taylor,
Chief of Bureau.

Hon. D. F. Houston,
Secretary of Agriculture.

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SITES, SOILS, AND VARIETIES FOR CITRUS GROVES IN THE GULF STATES.

INTRODUCTION.

The following pages contain brief and concise directions for the choice of the proper sites, soils, and varieties for citrus orchards in the Gulf States, being a revision of one part of the material formerly published in Farmers' Bulletin 238. It has been the aim of the writer to furnish information to meet the needs of many inquirers rather than to prepare a complete treatise on the industry.

The growing of the finest citrus fruits is a horticultural accomplishment not surpassed in any line of the art. There are very few agricultural occupations that require an equal amount of judgment and very few that give as remunerative a return for the mental outlay. Everyone who is willing to pay the price, either in labor or in dollars, can grow oranges and grapefruit, but only he who is so constituted as to derive pleasure from exercising his mental faculties to their fullest extent can produce fruit of the finest quality. There is a very long series of conditions, from the choice of the site to the delivery of the package of perfect fruit to the consumer, which must be met successfully. If any link in the chain is broken, first place can not be attained. Good judgment must be exercised in the choice of the stock, the bud, the soil, and the location of the crop, in the treatment of fungous and insect diseases, in picking and packing the fruit, and in selecting a market for its disposal.[1]

CLIMATE.

In general it may be stated that in all regions in which the temperature does not fall below 18° above zero nor rise above 100° F., under humid conditions, and where there is sufficient moisture, citrus fruits may be produced. However, there are localities within these limitations that can not be said to be good citrus-growing sections. In some places, although the trees grow luxuriantly, heavy rainfalls occur at the time when the fruits are maturing, making it impossible to gather and market them. In others the conditions for vegetative growth are so favorable that very little fruit sets. Regions that are excessively dry may, however, be utilized for citrus culture when irrigation can be practiced. The more nearly the northern limit of the citrus belt is approached, the more sprightly and deliciously flavored the fruit becomes, some of the very best fruit being marketed from areas where the trees are every winter in danger of being frozen.

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[1] These subjects can not all be discussed here, however, and the reader is therefore referred to the following Farmers' Bulletins: No. 539, entitled, "Propagation of citrus trees in the Gulf States;" No. 542, entitled, "Culture, fertilization, and frost protection of citrus groves in the Gulf States;" and No. 172, entitled, "Scale insects and mites on citrus trees."

The ideal humid climate for citrus growing is one in which the rainfall occurs after the fruit has been shipped and before the new crop begins to ripen. The rainfall should not be excessive, certainly not more than 50 to 70 inches annually, and the winter temperature should not go below 26° to 27° F. of continued cold, though a lower temperature may be withstood for an hour or more without killing the trees. Orange trees in a thoroughly dormant condition can withstand a temperature as low as 24° F., if this is not continued for more than a few hours at a time. A very sharp turn to 18° F., even if for only a few hours, will entirely defoliate trees in the most dormant condition, while it is likely to kill the larger proportion of those in active growth. Small trees under 8 to 10 feet high, with poorly protected trunks. are very liable to be killed to the ground under these conditions. Sometimes snow falls and remains on the trees for several hours without seriously damaging orange trees, but this is of rare occurrence.

SOIL.

It will be shown under the heading "Varieties" that citrus trees are exceedingly variable, and consequently will readily adapt themselves to almost any kind of soil in which plants can grow. Varieties of citrus grow upon the sticky, adobe soils of Mesopotamia, upon the alluvial soils of the lower Mississippi, upon the fertile soils of the West India Islands, upon the dry soils of Arizona and California, and upon the almost sterile, sandy soils of Florida. There is probably no other genus of fruit trees in which the species are so plastic as to adapt themselves to almost every possible gradation of soil. It should not be inferred, however, that every variety of the genus can be grown upon all of these different kinds of soil, for it is absolutely necessary to choose the particular variety which is adapted to any peculiar soil.

While the rich, alluvial soils produce citrus trees of rank growth which often bear enormous crops of fruit, the finest and highest priced fruits are produced upon the nearly sterile soils. In fertile soils the plant food is seldom properly balanced or present in the condition best suited for producing the finest fruits, nor is it possible to influence the contents or quality of the fruit by applying different forms of chemical fertilizers. If, therefore, a field is normally sufficiently fertile to produce a citrus crop for an indefinite number of years, it is usually impossible to influence the quality of fruit markedly by means of fertilizers. Upon soils which are nearly sterile, however, trees may be started and fed with just such chemicals as will produce the finest quality of fruit. It therefore happens that soils which formerly were considered absolutely worthless for agricultural purposes are now made to produce large crops of most excellent fruit.

SITE OF THE GROVE.

Immediately upon deciding to plant a grove the best site that can be procured should be selected. A great many questions arise in determining where a grove shall be located. A few of these are discussed below.

DISTANCE FROM TRANSPORTATION LINES.

Since the profit accruing from a grove is the grower's ultimate object, it becomes necessary to study the possibility of getting the fruit into the market cheaply. Long hauls by wagon over rough roads should be avoided wherever possible. Hauling by wagon is expensive and, what is more important, it consumes much time at a period when it is difficult to employ efficient labor.

The distance to which it is profitable to haul fruit will vary greatly. Hard-surfaced, smooth roads are found in nearly every progressive community. In some localities automobile trucks are employed for taking fruit from the grove to the central packing house, making the transfer charges low. The fruit is also less likely to be injured in transit. Under such circumstances a distance of 10 miles might be regarded as the maximum at which to start a grove. Under more adverse conditions one should not attempt to put out a grove at a greater distance from transportation facilities than 5 miles.

First-class citrus land can be purchased in nearly every favorable locality in Florida at prices ranging from $20 to $50 an acre. When located adjacent to hard-surfaced roads the price will vary from $40 to $100 or more an acre. Placing the average crop at 200 boxes per acre and the average cost of transferring the fruit from distant groves at 5 cents a box, the hauling charges would constitute a tax of $10 per year per acre against such property. This charge would be for the hauling of the fruit alone, and would not include the handicap in securing labor, hauling supplies, and fertilizers.

CHARACTER OF THE SOIL.

The variation of the soils in the West Indies and in Louisiana and Mississippi is not so sharply marked as that in Florida. There are, however, characteristic soils in each of these regions that are better than others. In all sections a soil must be chosen that is not underlain with a heavy substratum known as hardpan. The land should be elevated sufficiently to permit free drainage and in the sections where irrigation must be practiced should be so located that water can be easily supplied.

In Florida the soil usually known as hammock land is preferable for orange growing. This, however, is of limited extent and frequently is so far removed from transportation lines that it is not profitable to use it. The second grade is called piny woods land. Groves properly located on this type of soil and managed by intelligent superintendents frequently give the best returns. It is upon this land that most of the orange groves are located. The cabbage palmetto hammock, if sufficiently high to permit natural drainage, also makes excellent land for citrus growing.

DRAINAGE.

In Florida the question of drainage is of paramount importance. There is scarcely a large citrus grove in the State in which some section is not injured from time to time for the want of thorough and deep drainage. While the total annual rainfall is likely to vary within rather narrow limits, its distribution throughout the year will probably be exceedingly variable. The drainage system should be so constructed as to provide for periods of excessive rainfall rather than for the average of what might be expected. In choosing the site of a grove, one should ascertain that it is possible to dispose of the surplus water promptly. Groves have been situated near a lake or other body of water or on some site where it was impossible to dispose of the surplus water during a rainy period, and irreparable damage has resulted, although at the time of the excessive rainfall no iujury was apparent. As a general rule, the water table for Florida should not rise higher than within 18 inches of the surface of the soil. Other conditions being the same, the groves in which it is 10 feet or more to the water table suffer less during a severe drought than those where the water table rises almost to the surface. A fluctuating water table is more objectionable than a constant one, however, even when the latter occurs high in the soil.

Water standing in a grove for a few days is almost certain to prove fatal, while water flowing through the grove for the same length of time will only injure it. It takes years to grow a good grove, which may be destroyed or ruined in a week.

The important points in drainage, then, are to be certain (1) that there is no possibility of ever having standing water in the grove, and (2) that the water table is as deep as possible in the soil; the farther down the better.

NATURAL FROST PROTECTION.

After determining that the desirable features specified are to be found in the location under consideration, it is very important to see that the land is well protected from the occasional frosts which visit the citrus-growing sections.[1] Frost protection is imparted by large bodies of water, such as make possible citrus growing in Louisiana, in Mississippi, and in Florida near the lakes in the central part of the State, along the Indian River on the east coast, and on Tampa Bay. In the West Indies and the southernmost part of Florida this factor does not enter into consideration. In fact, it seems that those places in the West Indies which are subjected to the lowest winter temperature produce citrus fruits of the highest excellence. The temperature in the vicinity of Mandeville, Jamaica, is said to go as low as into the fifties during winter nights, and yet this is probably the best citrus fruit section on the island.

PROTECTION FROM HIGH WINDS.

A location chosen so as to combine all the qualifications already mentioned may still be undesirable if it is exposed to the force of high winds, which may occur in any portion of the country. It is quite impossible to protect a grove against tropical hurricanes, but the more common high winds of frequent occurrence must be considered. They carry off the moisture and bring with them a dry, parching air which is injurious to citrus trees, and they are also very likely to cause "thorning" or to mutilate the fruit in other ways. Sometimes it becomes necessary to erect artificial windbreaks for protecting a grove not well located. These artificial windbreaks may later be supplanted by some natural growth that can withstand the force of the wind.

RAINFALL.

The amount of rainfall needed to produce a crop of citrus fruits depends on various factors; prominent among them are character of soil and humidity of atmosphere. Where there is a deficiency of moisture it may be supplied by irrigation, but a superabundance of moisture can be controlled only in a measure by drainage. In the humid portions of the United States and in the rainy sections of the West Indies heavy rainfalls frequently occur at the time when the fruit should be marketed or when the trees should be dormant preparatory to blooming. As these conditions can not be corrected, citrus orchards should not be planted in regions where excessive fall or winter rains are prevalent. This is especially true of the rainy side of most islands in the West Indies group.

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[1] For a discussion of artificial frost protection, see Farmer's Bulletin 542, entitled "Culture, fertilization, and frost protection of citrus groves in the Gulf States."

VARIETIES.

The group of plants which is designated by the generic term "citrus" is fairly well circumscribed, but when it comes to a segregation of the different species and varieties scientists do not all agree. While it may be of interest to the scientific plant breeder to know just what the classification is, to the practical grower of fruits who wishes to get a large return for his labor it makes very little difference whether the product belongs to one variety or another. The results of the various attempts to classify the plants which fall under the general term "citrus" vary exceedingly, and differing opinions regarding their scientific relations are held by scientific investigators. There are therefore a number of different classifications. In Table I the writer has adopted the classification worked out by Dr. Herbert J. Webber in the Cyclopedia of American Horticulture.

TABLE I.—*Botanical and horticultural classes of the genus Citrus.*

Botanical species.	Botanical varieties.	Horticultural races.	Horticultural varieties.
I. *Trifoliata*			Trifoliatas.
II. *Aurantium*	*amara*		Sour. Bittersweet. Seville.
	bergamia		Bergamot orange.
	sinensis	The common oranges	Bahia. Valencia. Homosassa. Pineapple. (Also other varieties.)
III. *Nobilis*		The mandarin group	Satsuma. China (mandarin). Dancy (tangerine). Oneco. King.
IV. *Decumana*		Pomelo (grapefruit)	Royal. Pernambuco. Triumph. (Also other varieties.)
		Shaddock	Paradise. Forbidden Fruit. (Also other varieties.)
V. *Japonica*		Kumquats	Nagami. Marumi. (Also other varieties.)
VI. *Medica*	*genuina*	Citron	Corsican. Lyman. Orange. (Also other varieties.)
	lemon	Lemon	Lisbon. Villa Franca. Sicily. Eureka. (Also other varieties.)
	acida	Lime	Imperial. Mexican. Persian. (Also other varieties.)

Experience has taught that no variety of citrus is preeminently useful for all portions of the world where this fruit is grown. As an illustration we have the Bahia, or Washington Navel orange, which is preeminently adapted for California, but is of little value in Florida or the West Indies, where it produces only a small crop. Certain varieties of pomelo have an exquisite flavor when fruited in Florida, but are not of the same excellence when grown in California. The Pineapple orange and the Indian River orange are among the finest of fruits when grown in the sections where they originated, but when produced in Jamaica they can not be said to have superior qualities.

It becomes necessary, therefore, to test the particular variety in the section into which it is to be introduced. Some varieties are excellent in places far removed from one another, as is illustrated by the Satsuma, or Oonshiu, an introduction from Japan, and the Bahia orange, which was brought from Brazil by the United States Department of Agriculture and is now so extensively grown in California. The last-named variety produces fruit of excellent quality when grown in Florida, but, as stated, is not prolific. Frequently the most important varieties of citrus for any given locality are those which have originated as seedlings in that section, or have arisen as bud varieties. An illustration of a variety arising as a bud variation is the Surprise navel, originating in Mr. E. S. Hubbard's grove at Federal Point, Fla., from buds received from California. Seedlings, as a rule, "sport" or are exceedingly variable; they, however, come true to seed within certain limitations. So far as known, a pomelo can not originate from an orange seed, except where an orange flower is pollinated from a pomelo, and it is then not a true pomelo. Seedlings from the mandarin group reproduce a typical mandarin fruit. Seedlings from the sweet orange produce a typical sweet orange. Seedlings from pomelos produce pomelos of varying qualities.

The total number of varieties of citrus fruits that have been catalogued and described would run up into the thousands. Nearly every one has some peculiar merit for a particular locality. Out of the many thousands a few selected ones are of general value, and can be planted with safety over a considerable area. The following very brief list gives some of the varieties for the localities mentioned:

Florida.—The Florida State Horticultural Society has divided the State into four horticultural sections, known as western north Florida, eastern north Florida, central Florida, and south Florida.

Western north Florida includes that portion of the State lying west of the Aucilla River.

The main reliance in the citrus crop for that region should be in the Satsuma orange. Under special conditions this variety produces a most palatable and otherwise excellent fruit. Near the Gulf of Mexico, in frost-protected places, sweet seedlings, the Pineapple, Parson Brown, and other early-ripening varieties are planted in small orchards and are doing well.

Eastern north Florida includes "that part of the State between the Aucilla River and a straight line drawn across the State from the mouth of the St. Johns River to Cedar Keys."

The following citrus fruits are considered especially adapted for this region: Of the sweet-orange group, the Pineapple, Parson Brown, and Sweet Seville; of the tangerine group, the Satsuma; of the kumquat group, the Marumi and Nagami.

Central Florida includes "that part of the State between the line above referred to and the counties constituting south Florida."

Of the sweet-orange group well adapted to this section may be mentioned the Pineapple, Centennial, Tardiff, Homosassa, Jaffa, Majorca, and Parson Brown; of the mandarin group, the Satsuma, China, Dancy, and King; of the pomelo group, the Standard, Duncan, Excelsior, Hall, Marsh, and Royal.

Shaddocks and citrons are not grown as commercial fruits, and Nagami is the leading variety of kumquat for this section.

South Florida includes the following counties: Brevard, St. Lucie, Palm Beach, Lee, Dade, Monroe, De Soto, and Manatee.

The sweet oranges recommended for this section are the Hart, Valencia Late, Homosassa, and Majorca; of the mandarin group, the China, Dancy, and King; of the pomelo group, the Standard, Duncan, Excelsior, Hall, Marsh, and Pernambuco.

Shaddocks are not grown commercially and are found only as ornamentals or novelties. In the kumquat group the leading variety is the Nagami. Citrons are grown only as occasional specimens, and lemons are not grown extensively in Florida.

On the keys and the adjacent coast considerable quantities of limes grow without cultivation and are apparently naturalized. The United States Department of Agriculture has distributed various importations of limes in south Florida, and nearly all of these varieties do very well. The peculiar demands of the market, however, are such as to make extensive lime growing unprofitable. Nevertheless, very high prices are paid for the limes which are gathered from trees occurring spontaneously on the coast and keys. This lime is generally spoken of as the Key lime. It is a very small fruit and intensely acid and usually contains many seeds. This same lime when taken to the mainland and put under cultivation produces a large fruit with very thick, rough skin, approaching the lemon in size and appearance. Limes of this size do not meet with ready sale.

Louisiana and Mississippi.—The citrus-growing section of Louisiana and Mississippi closely borders the Gulf. In Mississippi it is near Biloxi, and in Louisiana it is south of New Orleans.

In these sections the common sweet orange grown is known as the Creole. This, strictly speaking, is not a variety, but an assemblage of seedling oranges that have been cultivated in this region for some time. Of the mandarin group the Satsuma and China are the leading varieties. Of the pomelo group only a few are grown, these being the earliest varieties, such as the Standard, Royal, and Triumph.

Texas.—Considerable activity in planting citrus fruits in the Gulf region of Texas has occurred in recent years. The main reliance has been placed in the Satsuma on *Citrus trifoliata* stock.

Porto Rico and the West Indies generally.—Citrus growing throughout the West Indies is in a rather formative state. The efforts at systematic work in this line have not been carried forward with the same degree of vigor as in California and Florida. Nearly all the varieties recommended for south Florida may be planted with more or less confidence in this region. After years of experimenting local varieties will doubtless develop which will prove better than many of those now cultivated on these islands.

A 1. 9: 539

Issued June 21, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 539.

PROPAGATION OF CITRUS TREES IN THE GULF STATES.

BY

P. H. ROLFS,

Director of the Agricultural Experiment Station
of Florida.

WASHINGTON:
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1913.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., March 27, 1913.

SIR: Many requests are received at the United States Department of Agriculture for information on the methods employed in growing oranges and other citrus fruits in Florida and the other Gulf States, and it is important that the Department be able to supply the desired information as fully as possible. In order to furnish this information in concise form, Prof. P. H. Rolfs, Director of the Agricultural Experiment Station of Florida, has revised Farmers' Bulletin 238, entitled "Citrus Fruit Growing in the Gulf States," and has divided the material contained in that publication into three parts, of which this paper is the second, as follows: (1) "Sites, Soils, and Varieties for Citrus Fruit Growing in the Gulf States"; (2) "Propagation of Citrus Trees in the Gulf States"; and (3) "Culture, Fertilization, and Frost Protection of Citrus Groves in the Gulf States." In this form the information will be more available for distribution in the territory directly concerned and will be of more service, it is believed, to prospective citrus-fruit growers and to planters already engaged in this industry. I have the honor to recommend that the paper be published as a Farmers' Bulletin.

Respectfully,

WM. A. TAYLOR,
Chief of Bureau.

HON. D. F. HOUSTON,
Secretary of Agriculture.

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PROPAGATION OF CITRUS TREES IN THE GULF STATES.

INTRODUCTION.

This bulletin is published to fulfill an urgent request from growers in the Gulf States for a brief description of the methods of propagating citrus trees and of the most important nursery practices. It includes also a discussion of the choice of suitable stocks for different regions. Because of the limited size of the publication and in order to make it applicable to Florida and the other Gulf States the questions have necessarily been treated in a very general manner.[1]

THE NURSERY.

The nursery is the starting point of the citrus grove. It is therefore one of the factors of greatest importance. No matter how well the climate may be suited to the growing of fruit or how well the grove may be cared for after it is planted, if improper selections have been made in the matter of stock or of buds, disappointment is just as certain as if improper selection had been made of the locality in which to grow the fruit.

SUITABLE STOCKS FOR DIFFERENT SECTIONS.

Each of the principal citrus-growing regions of the United States has a stock which is best adapted to its own peculiar conditions. Even in the larger citrus-growing regions the variations of soil are such as to demand different kinds of stocks or buds.

Louisiana and Mississippi.—In Louisiana and Mississippi the soil is a heavy clay, very fertile, and usually quite moist. *Citrus trifoliata*, or *trifoliata*, as it is commonly called, is preeminently the stock for use in this section. Here it not only is a vigorous grower but also imparts more or less of hardiness to the scion by becoming dormant in the autumn, since the *trifoliata* is a deciduous species (fig. 1).

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[1] For discussions of other phases of this industry, see Farmers' Bulletins 538, entitled "Sites, Soils, and Varieties for Citrus Groves in the Gulf States"; 542, entitled "Culture, Fertilization, and Frost Protection of Citrus Groves in the Gulf States"; and 172, entitled "Scale Insects and Mites on Citrus Trees." A Farmers' Bulletin on the harvesting and marketing of citrus fruits is in preparation.

Eastern north Florida.—In the eastern part of north Florida the *trifoliata* is also the best stock to use, for the reason given in the preceding paragraph. Much of this region is also a rather heavy, sandy soil inclined to become clayey. In the deep, sandy portion of this section some of the more rampant-growing stocks do equally as well as or possibly better than the *trifoliata*, but they do not produce quite so hardy a tree.

Central Florida.—Throughout central Florida the soil is inclined to be sandy, but usually contains a considerable quantity of decaying vegetable matter. On this soil the pomelo stock does best, although it does not make quite so hardy a tree as the sour-orange stock.

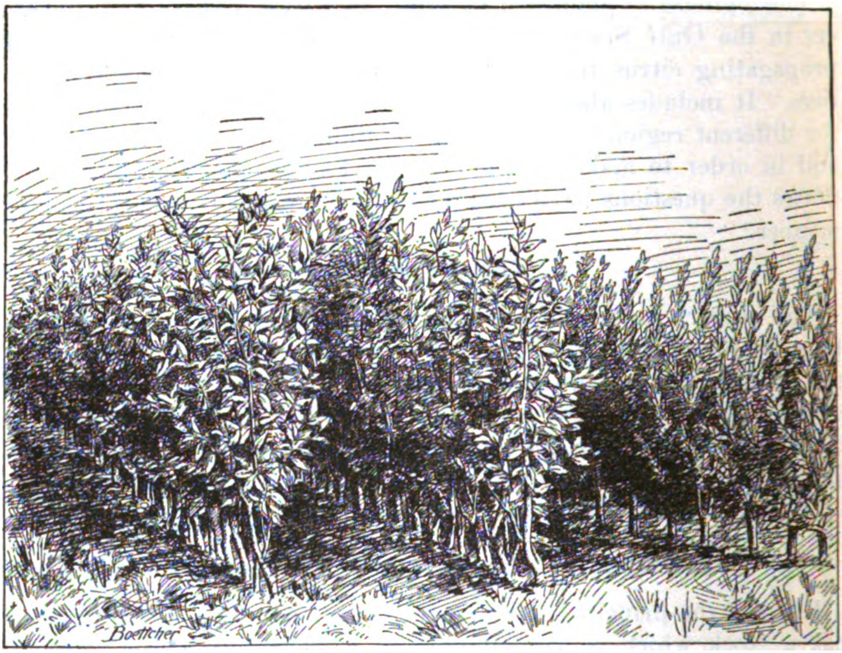

FIG. 1.—Citrus nursery at Naomi, La.: Trifoliata stock and mandarins to right; pomelos to left. Buds of one summer's growth.

South Florida.—The rough lemon is preeminently the stock adapted for use in south Florida. It is a rampant grower, able to live on soils that are almost sterile for the other stocks mentioned, but is inclined to produce a little more coarse fruit than the other stocks. In the heavy soil of this section, especially that which is free from limestone, the pomelo and sour orange may be used to good advantage. These trees are somewhat slower in growth, but produce a more smooth and velvety fruit and ripen more evenly. The lime seedlings have also been used for stocks in this section. This makes a tree rather sensitive to cold, and the earliest crops of the fruit are inclined to be somewhat rough and thick skinned. The greatest drawback, however, from the nurseryman's point of view, is that the ordinary operation that would make 90 per cent of the buds live in rough-lemon stock would probably not give more than 50 per cent in the lime stock. It is therefore used very little.

SELECTING SEEDS.

In selecting seeds from which to grow nursery stock, one should choose well-matured specimens. It is a matter of indifference as to the perfection or imperfection of the fruit from which the seed is taken, but the seed should be plump and well filled and the fruits taken from the most vigorous trees. This is true for all the varieties that are to be used as stock. One is frequently able to secure a lot of pomelo drops and culls and from these secure large numbers of fine seeds.

There are various methods of obtaining seeds from the fruit. Where fruit has been damaged and thrown out to rot, the seed may be washed out from the rotting mass and the superfluous water dried off. The seed may be separated fairly easily by using an ordinary sieve with large openings and forcing the water on the seed by the use of a force pump or from a tank.

After gathering these fruits they are cut into sections with a dull knife and most of the seeds pressed out, and the cut sections are thrown into a barrel and covered with water. In a short time this mass will be sufficiently disintegrated to allow easy separation of the remainder of the seed. Care must be taken, of course, not to let the material remain in the water long enough to injure the seed. If the barrel is placed in a warm location, in two or three days the seeds will slip out easily, and they can then be separated from the pulp by washing.

The seeds that are squeezed out by hand need no special washing. They should be placed in the open in a shed to allow the superfluous moisture to dry off and then are ready for preservation. Bonavia says that in India the seeds "are well dried in the sun for two or three days."

KEEPING SEEDS.

In the northern sections of the citrus-growing regions the seed must be kept for a considerable time before the ground is sufficiently warm to receive it. After the superfluous moisture has dried from the seeds, which will occur in the course of from one to three days, they may then be preserved in dry sand. Where sand is not readily obtained, a fairly dry clay, such as will break up readily but which is not moist enough to pack, will be found useful. In this kind of material the seeds of *trifoliata* have been shipped from Japan to Florida and have retained their germinating qualities perfectly.

PREPARATION OF THE SEED BED.

Where only a few thousand seeds are to be planted they may be germinated in boxes or trays. Taking a box which is about 8 or 10 inches deep, with its other dimensions of convenient size, 3 or 4 inches of soil are placed in the bottom. The seed may then be sown on this layer of soil and an inch more of soil placed over them. Over this a layer of mulching, such as decayed leaves or sphagnum, or, in fact, anything that will keep the soil from drying out, may be placed, and in this the seed may be allowed to germinate and seedlings grown. The mulching should be removed as soon as the seedlings begin to come up.

The ordinary seed bed, or cold frame, as it is usually prepared by gardeners, is also an excellent place to germinate the seed and grow seedlings. In planting in beds of this kind the rows should be made 6 inches or a foot apart and the seeds dropped at the rate of one or two dozen to each foot of row. The seedlings may be left there until they have grown sufficiently large to be planted in the nursery.

For growing seedlings on a large scale, where hundreds of thousands are to be grown, it becomes necessary to make a careful selection of the spot where the seeds are to be planted. A place that is not in danger of being flooded or becoming too wet, and yet that will remain constantly moist, should be chosen. This land should be thoroughly broken up, plowed deep, especially if it is of a heavy or clayey nature, the rows laid off from 2 to 4 feet apart, according to conditions, and the rows then opened and a liberal application of fertilizer made. If the site happens to be a clay soil it is well to break the rows at least 10 inches deep. Fertilizer is then scattered down the rows and worked in thoroughly by the usual farming implements. From two weeks to a month after the seed bed has been prepared in this way the seed may be sown. The furrows are thrown open 5 inches deep and the seed scattered down the rows, being sufficiently distributed to give each seed an inch or so of space. The rows may be made from 4 to 8 inches wide, according to the needs and conditions. The seeds are then covered about an inch deep and the soil firmed about them. If drought follows the planting it may become necessary to resort to watering to keep the seed from drying out.

TIME OF SOWING.

The best time to sow depends upon the location of the seed bed. In southern Florida and the West Indies the seed may be sown as early as December. In central and northern Florida, and in Louisiana, Mississippi, and California, it is better to wait until the soil has warmed up sufficiently to induce rapid germination and active growth. This time may be reached anywhere from the first of February until about the middle of March or later, varying in different seasons and in different localities.

CULTIVATION OF THE SEED BED.

The cultivation of the citrus seed bed is the same as that usually given to seeds of garden crops. At first a light working, such as may be done with a garden rake, will be most useful. A skillful laborer may rake over a seed bed when the seedlings are coming through the ground with entire safety to the small plants. This raking may seem quite useless in many instances, but it is very important in that it conserves the soil moisture and breaks the crust if there is any tendency to form a hard surface. The middles may be cultivated with the usual shallow-going farm tools—a spring-tooth cultivator, a special harrow, or a hand plow. Cultivation should be repeated every week or ten days, and as the seedlings grow stronger the cultivation in the clay soils should be made deeper, until in midsummer or early autumn it has reached the maximum depth of farm cultivation. On the sandy lands cultivation should never be more than 3 or 4 inches deep, for on such lands the soil is already sufficiently loose and further stirring does not add to its productiveness.

TRANSPLANTING.

Under favorable conditions the seedlings will have attained a height of from 6 to 12 inches and the diameter of a small pencil by autumn or by the next winter. The seedlings are then in good condition for transplanting. The best time for transplanting is less definite than that of sowing the seed. In the West Indies and southern Florida transplanting may be done with good success any time after the seedlings are of sufficient size, depending on the favorable condition of the soil. In other citrus-growing regions transplanting is done in the spring or early summer, whenever favorable climatic conditions occur. Under some conditions seedlings are permitted to remain in the seed bed for nearly two years.

In preparing for transplanting on a large scale the nurseryman frequently uses a tree digger to run under the seedlings. This loosens up the ground on both sides, and at the same time cuts most of the taproots. The depth to which the tree digger should be run will depend on the amount of root growth the seedlings have made. In heavy soils transplanting is much facilitated by plowing a deep furrow on each side of the seedling row. A heavy spade may then be inserted under the row, and the seedlings lifted without much damage to the root system. Some means for keeping the roots moist after they have been removed from the ground should be provided.

PREPARATION FOR THE NURSERY.

The location of the nursery is of very considerable importance. The land selected can usually be slightly more moist than such as would ordinarily produce a good grove, but to be successful it should not be subject to flooding, nor should it be subject to drying out during severe droughts. The rows should be laid off from 4 to 6 feet apart, thoroughly broken out to a considerable depth, say about 10 inches, and then prepared in the usual manner in which gardeners prepare their land for vegetables.

Thoroughly rotted stable manure will be found an excellent fertilizer in heavy clay soils. In the soils that are inclined to be sandy, commercial fertilizers will be found of greater advantage. The quantity of manure and fertilizer to be used will depend on the fertility of the land to be planted. Upon the ordinary sandy soils from 500 to 1,000 pounds will be found entirely sufficient for the first application. On rich clay soils well-rotted stable manure at the rate of several loads to the acre will be found sufficient.

The rows should be prepared thoroughly and the land made ready about a month before the probable time for setting out the nursery stock. After the land has been prepared it will do no special harm if one has to wait longer than was expected before a favorable time for transplanting arrives.

When the time for transplanting arrives the seedlings may be taken out of the seed beds and transplanted into the nursery rows in various ways. The trees should be set about a foot apart in the row. Many nurserymen prefer to use a thin spade for transplanting, running this into the ground, bending it over, and setting in the tree. In this operation one man uses the spade while another man inserts the tree. When the spade is withdrawn, each man presses a foot near the tree and firms the soil tightly about it. In other cases the nurseryman prefers to simply run a furrow or double furrow down the row, set the tree firmly into position by hand, and then fill in the soil with a plow.

In setting the seedlings they should be placed so that the level of the soil is approximately at the same height on the seedling as when it grew in the seed bed. If the trees happen to be set an inch or so lower it will be of no serious disadvantage. In this work of transplanting, all small and inferior seedlings should be thrown out, as in all probability they will make only second or third rate nursery stock and will prove to be poor trees in the grove. What is wanted of nursery stock is a tree that has vigorous growth.

CULTIVATION OF THE NURSERY.

The cultivation of the nursery may begin immediately after the seedlings are set out. The cultivation at first need not be deep, merely running over with the finishing tools to conserve the moisture and keep the ground in good condition. Where the soil is sandy the cultivation at no time need be much more than this. In the heavy clay soils it is important to break up the soil as deeply and thoroughly as possible. The length of time elapsing between repetitions of cultivation will depend upon the condition of the soil. In all of the work of cultivating citrus trees it should be remembered that the destruction of weeds is of secondary importance. Of course this should never be neglected, but the real value of cultivating lies in the fact that the soil is kept in a suitable condition of aeration. If a heavy, beating rain falls immediately after cultivating, much of the good effected by the work is lost, and consequently another cultivation should be made as soon as the soil conditions will permit.

SEEDLING GROVE.

In the early history of the citrus industry main reliance was placed on the propagation of trees from seed. Such trees, when grown to fruiting age, are usually spoken of as seedlings. The use of seedling groves has been almost entirely superseded by budded groves. At the present time very few seedling groves are being planted. If one wishes to plant a seedling grove it is of the utmost importance to make a careful selection of the tree from which the seeds are taken. The parent tree should be a uniformly heavy cropper and one that produces superior fruits of the kind desired. Even with all of these precautions there is less certainty as to the quality and quantity of fruit that will be produced than where budded trees are planted.

Another disadvantage of planting seedling groves is that such trees are later in coming into bearing than budded trees and as a rule are of a more upright growth. The vigor of seedling trees is usually greater than that of the ordinary budded grove, but this is practically the only strong argument in favor of a seedling grove.

PROPAGATING BY CUTTINGS.

Lemons, limes, pomelos, and other citrus species may be propagated very readily from cuttings. The cuttings should be made from fairly matured wood and at such time of the year as will give considerable moisture to the soil and at the same time considerable warmth. While these cuttings have been employed for producing nursery stock on which to bud they are not so satisfactory as seedlings. The growth is somewhat slower and not as straight. Root cuttings from these various species may also be employed, but these have the same disadvantages that are encountered with the use of cuttings from the branch.

BUDDING.

There are various methods of propagating citrus trees—by budding, grafting, or inarching. While there are conditions under which grafting becomes necessary and when inarching must be practiced to obtain the desired end, budding is preeminently the best method of propagating citrus trees. The work is done so easily and may be accomplished with such certainty of good results that grafting and inarching as methods of increasing the stock of any particular variety must be considered obsolete.

The subject of budding was well covered by Dr. H. J. Webber in his paper entitled "Methods of Propagating the Orange and Other Citrus Fruits," which appeared in the Yearbook of the United States Department of Agriculture for 1896, and as no important improvements have been made since that date the following chapters, with the exceptions of those on time of budding and on cutting buds, are quoted without modification.

TIME OF BUDDING.

In regions where a more or less definite winter occurs, budding is practiced either late in the autumn, about November or December, and called dormant budding; or in the spring, after a vigorous growth has started. Good citrus stock may be budded at almost any time of the year, except during the winter in those sections where a decided lowering of the temperature occurs. In general it may be said that buds may be inserted at any time of the year when the bark of the stock separates easily from the wood. This always indicates a strong flow of sap.

CUTTING BUDS.

Some experienced nurserymen prefer to cut the bud sticks and keep these for a few days or several weeks before inserting the bud. It is thought by them that a larger percentage of the buds will take under these conditions.

SELECTING BUDS.

Bud wood should always be selected from fairly well-matured wood of the current year's growth. Round sticks (or as nearly round as possible) should be selected. The young growth of orange wood is at first angular, becoming rounder as the twig matures. The basal portions of the young branches, which are nearly or quite round (fig. 2, *a*), supply the best buds, with the exception of the first two or three, which are usually somewhat imperfect and should be discarded. Where it is difficult to secure well-rounded wood, angular wood which is not too soft (fig. 2, *b*) may be used. This, however, is not quite so satisfactory. Thorny bud wood should never be used when other wood can be obtained. Thorny trees are very undesirable, and a careful selection of thornless bud wood will soon result in thornless trees. The thorns have been bred out of many of the best citrus varieties, and if nurserymen would exercise proper care all the desirable varieties could soon be rendered thornless.

After cutting, the leaves should be pruned off and the twigs cut into sections of the desired length. To preserve the bud wood until needed the twigs should be tied up in convenient-sized bundles, carefully labeled, and packed in old sawdust in a box of suitable size. The box should then be closed and buried in sheltered ground several inches below the surface. In this way bud wood can be preserved in good condition for from two to three months. Dampened sphagnum, or peat moss, may be used instead of sawdust, but in this case considerable care must be exercised to get the moss properly dried. It must be moist, but not wet, for if too wet the bud wood may mold. The same caution applies also to sawdust. In this case the proper degree of moisture can be secured by taking the material from the interior of an old pile. Sawdust does not lose its moisture readily and is the best material for packing. Some simply bury the bud wood in the soil under shelter, digging down until the moist earth is reached.[1]

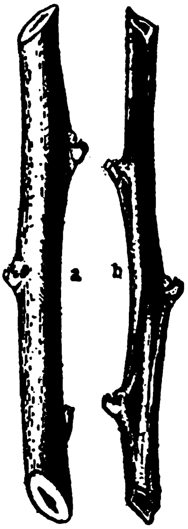

FIG. 2.—Sweet-orange twigs: *a*, Round twig of select buds; *b*, angular twig of buds. (From Yearbook, U. S. Dept. of Agriculture, for 1896.)

MATERIALS FOR BUDDING.

Before beginning the operation of budding, material should be provided for wrapping the buds. For this purpose cotton cord, yarn, strips of waxed cloth, etc., are used. The last named has practically superseded all others in Florida, being more convenient and giving better results than any other wrapping material. The strips are made from strong muslin or calico. Before the cloth is torn into strips it is folded into convenient size and dipped into a hot solution of wax made by melting together two parts of beeswax and one part of rosin. Several formulas for making this wax are used, any one of which will probably answer. The method described is known from personal experience and observation to give good results. After saturating the cloth with the hot wax, all the superfluous wax should be removed before the cloth cools. To accomplish this quickly, hang the piece of cloth, folded in convenient form before waxing, over a small, strong stick (fig. 3, *a*), which is held by an assistant. Then take two similar sticks of wood, and holding them parallel on either side of the cloth (fig. 3, *b*), press them firmly together and pull downward, squeezing out the superfluous hot wax. The cloth should then be spread out until cool, after which it is ready to be torn into strips of the desired size—that is, one-fourth to one-half inch wide and from

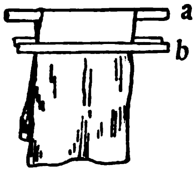

FIG. 3.—Strip of budding cloth, showing method of removing surplus wax. (From Yearbook, U. S. Dept. of Agriculture, for 1896.)

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[1] The clean, long sawdust from cypress shingles will make an excellent packing material.—P. H. R.

10 to 12 inches long. The cloth may be torn into strips before it is taken into the field or it may simply be torn into convenient-sized pieces and afterwards torn into strips in the field as desired for use. The latter is probably the most convenient way.[1]

Using waxed cloth for wrapping effectually excludes moisture, prevents the bud from drying out, and the work can be done more quickly than with string, as the strips cover more surface and do not require tying, the wax serving to hold the cloth firmly in place. It may therefore be recommended as far preferable to any other wrapping material.[2]

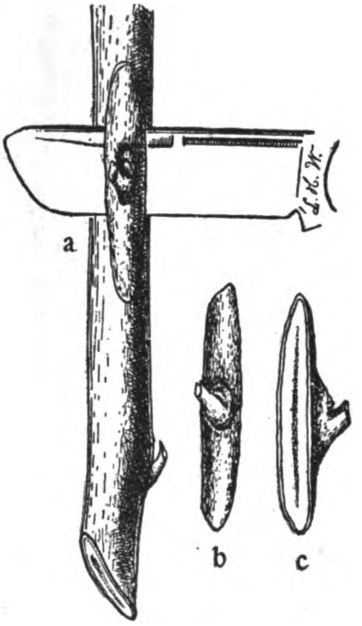

FIG. 4.—Shield or eye buds: *a*, Method of cutting bud from round twig; *b*, bud cut ready to insert; *c*, face of bud showing the cut surface. (From Yearbook, U. S. Dept. of Agriculture, for 1896.)

HOW TO BUD.

Budding is a simple process, consisting in inserting a bud of a desired variety under the bark of the stock in such a way that the freshly cut inner bark of the bud comes in close contact with the layer of growing wood (cambium) of the stock. The bark is closed over the inserted bud and the stock wrapped with waxed cloth, as described, so that the bud is firmly pressed against the growing wood. If the operation is properly performed, the tissue of the bud and stock soon fuse together and the bud may be forced to grow.

In all varieties and stocks of citrus fruits the process of budding is practically the same, the method commonly employed being that known as shield or eye budding (fig. 4). The bud is inserted in the young stock near the ground. Previous to the severe freezes of the winter of 1894–95 the general practice was to insert the buds 12 to 18 inches above the ground, but since then the tendency is to bud as near the surface of the soil as possible, so that the trees may be readily banked with the earth above the bud to protect against injury from freezes. Most of the buds are now inserted from 2 to 6 inches above the soil. In sections where foot-rot is abundant and sour-orange stock is used as a preventive measure the buds should be inserted from 12 to 18 inches above the soil, so that the sweet-orange wood will be above the influence of the disease.

All leaves and limbs which would hinder the proper wrapping of the buds should be cut away with a sharp budding knife. The use of sharp tools is the secret of success. A vertical cut about 1½ inches long is made at the point where the bud is to be inserted. At the base of this a horizontal cut is made, so that the two cuts present the appearance of an inverted T (⊥), as shown in fig. 5, *a*. The cuts should not be deep. The aim should be to merely cut through the bark, but no injury will result if the cuts are rather deeper. The lower edges of the bark are slightly raised with the end of the knife blade (fig. 5, *b*) to facilitate the insertion of the bud. This may also be accomplished by giving the knife an upward turn after making the horizontal cut. Now, take a stick of bud wood in the left hand and cut out a bud, as illustrated in fig. 4. Formerly the portion of the wood cut out with the bud was removed, but experience has shown that this is entirely unnecessary. The upper end of the bud is inserted under the slightly raised ends of the bark (fig. 5, *c*) and gradually pushed upward until all portions of the cut face of the bud come in contact with the wood of the stock (fig. 5, *d*). If in proper condition for budding, the bark of the stock readily separates, allowing the bud to be pushed upward into position. The bud is now ready to wrap. Take a strip of the waxed cloth prepared as above, and beginning slightly below the horizontal cut wrap tightly around the stock over the bud in a spiral manner, each turn slightly overlapping the previous one. The wax holds the cloth in place and makes it possible to draw it very tight. When the vertical incision has been entirely covered, turn the end of the strip slightly downward over the wrapped portion, to which it adheres more firmly than it would to the bark, and no tying will be necessary (fig. 5, *e*). It is better to wrap from below upward, as in this case each turn overlaps the other in the right direction to prevent water running down the stem from entering. Nurserymen usually wrap over the bud, covering it entirely. Some, following the practice commonly used with other fruits, leave the eye of the bud exposed. This, however, is more troublesome and does not succeed so well.

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[1] The waxed cloth may be torn in strips half an inch wide and the length of the cloth and wrapped into balls. In wrapping the balls each new piece added is slipped about half an inch under the former piece. These balls make a very convenient method of carrying the waxed cloth into the field.—P. H. R.

[2] The choice of wrapping material is an individual and a local affair. Some nurserymen use only raffia and have nearly perfect success; other nurserymen use only cotton wrapping twine and their buds take almost perfectly. They are located in the moister sections, where buds are not likely to dry out.—P. H. R.

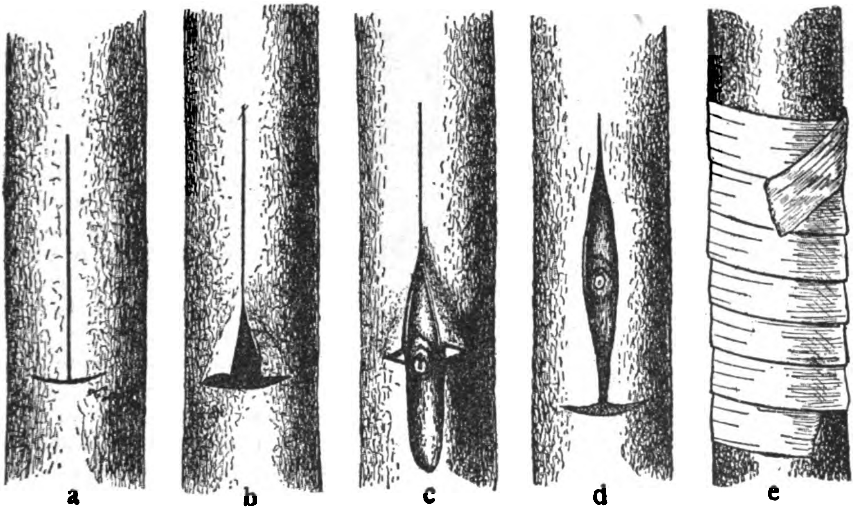

FIG. 5.—Shield or eye budding: *a*, Incision on stock; *b*, incision with lower ends of bark raised for inserting the bud; *c*, bud partially inserted; *d*, bud inserted ready to wrap; *e*, bud wrapped with waxed cloth. (From Yearbook, U. S. Dept. of Agriculture, for 1896.)

In some cases where bud wood of certain varieties is difficult to secure, it may be desired to use buds from the young angular wood (fig. 2, *b*). This may be used with good results if the stock to be budded is growing rapidly and is in a succulent condition. In this case the method of cutting and inserting the bud is slightly different from that already described. In cutting the buds the stick is turned slightly to one side, so that as the bud is cut off the eye lies on one side instead of in the center of the bud (fig. 6, *a*, *b*, and *c*). It is only by cutting the bud in this way that the cut surface is made wide enough to hold the bud firmly in position. For inserting these buds an incision is made in the bark, as shown in fig. 5, *a*. The bark is slightly raised on one side with the point of the knife and the bud is slipped under in a lateral direction, the eye remaining in the vertical slit (fig. 6, *d*). The bud is then wrapped as shown in fig. 5, *e*.

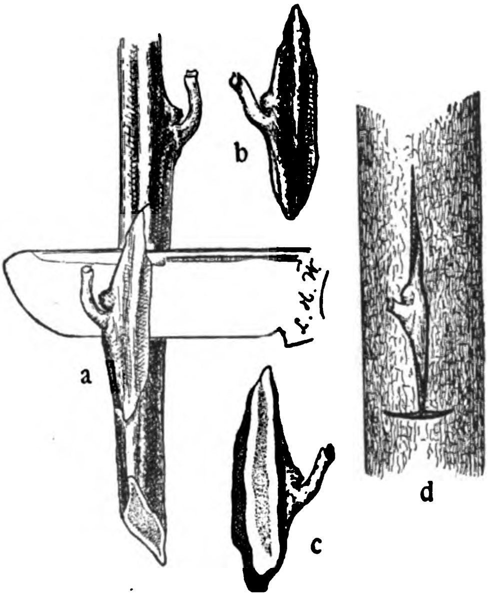

Fig. 6.—Shield budding with angular wood: *a*, Cutting the bud; *b*, bud cut ready to insert; *c*, bud showing cut face; *d*, bud inserted, bark on right side only being raised. (From Yearbook, U. S. Dept. of Agriculture, for 1896.)

UNWRAPPING THE BUDS.

In from 10 to 12 days the buds will have united with the stock and may then be unwrapped. In early spring, when the weather is cool and the growth slow, the wrapping should be left on from 15 to 20 days, while in the summer when the weather is warm and the growth rapid, 10 days is usually a sufficient length of time. However, it is impossible to say definitely how much time should elapse before the wrapping should be removed, as the wood of the stock should never be allowed to grow over the buds. It should not be removed until a light grayish line of new tissue can be seen forming around the edge of the incision made in inserting the bud. A little experience will enable one to tell at what stage it is safe to unwrap. Under ordinary conditions from 12 to 15 days will give good results, but in very dry weather in the summer, when growth is slow, it may be necessary to leave the wrapping on for a longer time. Some 10 days after budding an examination should be made of a number of the buds, and if they are found to be well healed on, the wrapping may be taken off; but if not, the wrapping should be replaced and allowed to remain some time longer. If the wraps are allowed to remain too long, the wood of the stock is likely to grow over the buds and greatly hinder their pushing.

FORCING THE BUDS.

In order to force the buds to push uniformly after they have healed on, it is necessary to severely check the growth of the stock. This is most commonly accomplished in nursery trees by lopping the tops, as it is called, which is usually done from 3 to 5 days after the wraps are removed from the buds. The lopping is usually done with pruning scissors, the knife edge being placed about 2 inches above the bud and the stock cut two-thirds through. The top is then bent over to one side and allowed to rest on the ground (fig. 7, *a*).

To provide for subsequent cultivation and attention it is necessary to use some definite plan of budding and lopping in the nursery. Two methods most commonly followed by Florida nurserymen are to lop the tops of two adjoining rows into the same center (fig. 8, *a*), keeping the alternate centers free for cultivation, or to lop the tops of alternate rows in different directions, one row in each center (fig. 8, *b*), and place them near the rows. By the latter method a cultivator may be run up one row and down the other, passing always in the direction in which the tops are inclined so that the branches will not interfere with the cultivator. Usually the old tops are allowed to remain attached until the buds have attained a height of from 12 to 18 inches, after which they may be cut off.

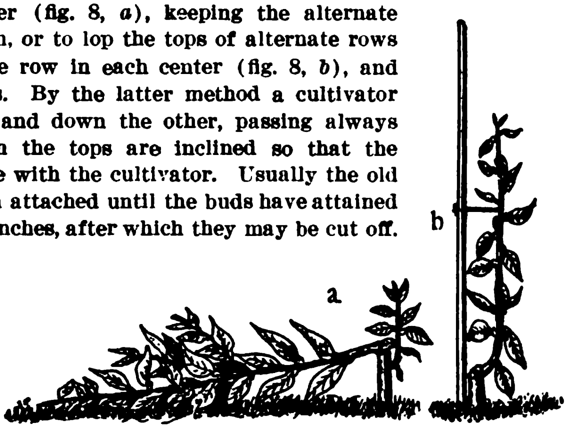

FIG. 7.—Treatment of buds: *a*, Young tree lopped to force bud; *b*, bud and supporting stake after "lop" has been removed. (From Yearbook, U. S. Dept. of Agriculture, for 1896.)

Some nurserymen have found that the buds make a larger growth if the old tops are allowed to remain attached through the summer and are cut off in September. If this practice is followed, two rows of trees should be lopped together. The tops thus form a dense shade or sort of mulch on the soil, keeping it moist and preventing the weeds from growing. In this case it is also desirable that the rows lopped together should be planted rather close (about 3 feet apart), for if this is not done the weeds will grow up among the tops, making it necessary to cut off the latter when the buds are 1 foot to 18 inches high in order to keep the weeds down. In the case of vigorously growing stocks, like the rough lemon, it is said to be very desirable to leave the tops attached for some time.

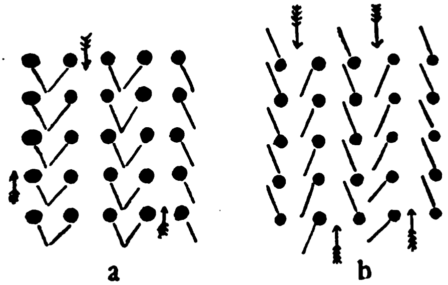

FIG. 8.—Diagrams illustrating methods of lopping nursery trees: *a*, Lopping two rows in one center, leaving alternate centers free for cultivation; *b*, lopping alternate rows in opposite directions. (From Yearbook, U. S. Dept. of Agriculture, for 1896.)

When the old tops are removed, the portion remaining above the bud should be cut off smooth and close to the bud, so that it will soon heal over without forming an ugly scar (fig. 7, *b*). Some follow the practice of coating the freshly cut end with shellac, but others working on an extensive scale never do this. It is seldom that any noticeable benefit is derived from the practice.

GROWTH OF THE BUDS.

The attachment of the rapidly growing bud is at first very weak and it is necessary to strengthen it by tying to a stake (fig. 7, *b*). Some nurserymen practice cutting the stock rather high in lopping, and support the buds for a time by tying them to the remaining portion of the stock. The buds push much better, however, when the stocks are cut very close in lopping, so that it is hardly desirable to depend upon this method of supporting the buds, as in either case it is necessary later to supply the supporting stakes. (See figs. 7 and 9.)

The development of the buds should be carefully watched during summer, and they should be pruned in such a way as to produce a top of the desired shape. In Florida, where a low tree is desired, it is necessary to nip the tops when they are 2 or 3 feet high to induce branching. The buds which push low down on the stock or bud should be rubbed off before they have grown to any size, as their growth detracts from the development of the bud.

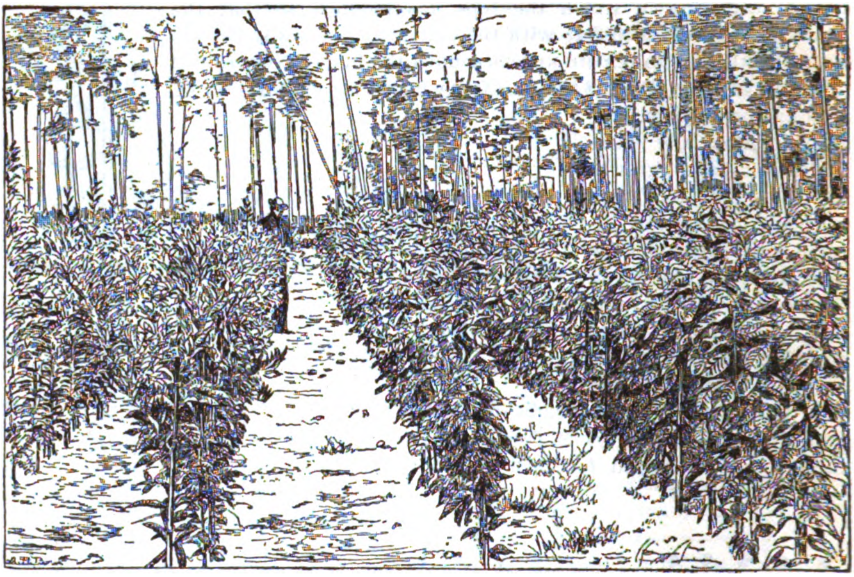

FIG. 9.—Arrangement of stakes in a nursery. (From Yearbook, U. S. Dept. of Agriculture, for 1896.)

DORMANT BUDDING.

Putting in buds which are intended to remain dormant during the winter, or dormant budding, as it is called, is usually done in October or November. The process is exactly the same as described above, except that the tops are allowed to remain standing until the following spring. They are lopped in the usual manner the latter part of February, or just before the spring growth starts. The advantage of dormant budding is to secure the first spring growth in the bud, which is the largest growth in the year.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 540.

THE STABLE FLY.

BY

F. C. BISHOPP,
Entomological Assistant.

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LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Entomology,
Washington, D. C., April 15, 1913.

Sir: I transmit herewith a manuscript entitled "The Stable Fly," by F. C. Bishopp, of this bureau. This insect is a pronounced enemy of domestic animals, frequently, as in the season of 1912, causing much loss among cattle and horses. It also becomes of great importance on account of its proved carriage of the disease known as "infantile paralysis" among human beings, and of its suspected carriage of pellagra. It is important that stockmen and medical men should know at an early date everything possible about this pest, and the accompanying manuscript has been prepared for this purpose. I recommend that it be published as a Farmers' Bulletin, in order to enable its wide distribution.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. D. F. Houston,
Secretary of Agriculture.

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THE STABLE FLY.

INTRODUCTORY.

The wide distribution of the stable fly (*Stomoxys calcitrans* L.), its intimate association with man, and its close resemblance to the so-called house fly or typhoid fly (*Musca domestica* L.) have led many to consider it identical with that species. Not until the stable fly becomes so numerous as greatly to harass live stock, or until the acute pain which accompanies the insertion of its proboscis is felt by the farmer himself, is man usually brought to a realization of the presence of a fly different from that distributor of typhoid germs, the common house fly. Severe outbreaks of the stable fly have led many to observe the flies more closely and to note their identity. Thus many individuals in certain sections speak of the stable fly as the "wild fly," "straw fly," or "biting house fly," to differentiate it from the ordinary house fly. The common name "stable fly" is applied to it because of its continual presence around stables, except during cold weather, and its comparative scarcity about the dwellings of man. Until very recently the stable fly received little attention at the hands of the entomologist or others. The recent demonstration by Drs. Rosenau and Brues of the possibility of the transmission of a distressing disease of man, known as infantile paralysis, through the agency of this fly, greatly stimulated interest in the study of the insect. A similar effect was also produced by the possible connection of this pest with the transmission of pellagra in man, as pointed out by Messrs. Jennings and King of the Bureau of Entomology. The investigations of authorities in this and other countries indicate that an important relation exists between certain diseases of domestic animals and this fly. Aside from the rôle played by the insect in disease transmission, it is an all-too-common and persistent pest to domestic animals. It will thus be seen that the stable fly may be of importance in three ways, namely, as a tormentor of live stock, as a carrier of diseases of domestic animals, and as a transmitter of diseases in man.

DISTRIBUTION AND ABUNDANCE.

The stable fly is one of the most widely distributed of insects. It appears to occur commonly in all parts of the world inhabited by man and the larger domestic animals. In those parts of the tropical, subtropical, and temperate regions in which domestic animals are reared, especially where those animals are kept in considerable numbers, the fly is a pest of importance. The absence of severe cold in the winters and the moist warm conditions prevailing in many of the countries bordering on the Tropics allow almost continual breeding; hence in these regions the fly is of importance throughout the entire year.

The stable fly has been in the United States for many years. Although it is probable that it was introduced from Europe with live stock brought here by the earliest colonists, we have no definite knowledge regarding its first occurrence in this country. The strong flight of the fly and its close association with domestic animals has permitted it to spread to all parts of the country.

The abundance of the species appears to be dependent largely upon local and seasonal conditions. In the southern part of the United States the insect is a pest of more or less importance throughout the year, but is usually most abundant in the latter part of the summer and during the fall. In the North and West it seldom becomes sufficiently numerous to cause annoyance to stock until the latter part of the summer and the early fall, the injury diminishing rapidly after heavy frosts. It appears that the fly is of much more importance as a pest in the grain belt than elsewhere. This point will be discussed more fully in another part of the paper.

From time to time climatic and other conditions have been favorable for the production of flies in great numbers, but little definite information is at hand regarding severe outbreaks which occurred prior to 1912. Old residents in the north-central part of Texas state that exceedingly large numbers of flies were present during the summer of 1867. Another outbreak occurred in parts of Texas in 1894 or 1895, and in 1905 the flies were again numerous enough to cause serious loss.

Notes have been published from time to time, in early entomological papers, on the injuriousness of this insect. In September, 1888, we find in Insect Life a reference to it as a pest to horses in Oregon. The correspondent in this case stated that the fly made its appearance at Salem, Oreg., two or three years before, though this information can scarcely be considered as reliable. This same issue of Insect Life also includes the statement that in the spring of 1888 the fly was reported to have caused considerable annoyance to cattle in Maryland and New Jersey.

In Kansas and Nebraska it has been determined that it is a pest of some importance every year throughout the grain belt of those States, but occasionally it appears in much greater numbers than normal. Statements made by farmers in other sections of the country where grain is grown extensively, notably in the Dakotas and Minnesota, indicate that the fly is sufficiently numerous nearly every year to cause considerable trouble. In the Southwestern States it sometimes becomes very abundant, although records of serious outbreaks have not been made. In central and southern Louisiana it is often very annoying to all live stock. This is especially true in the region where rice is grown extensively. It appears from investigations conducted in the central part of Florida that the stable fly is seldom present in sufficient numbers to attract attention. Prof. C. P. Gillette, of the Colorado Agricultural College, says in a recent letter, "Possibly the common stable fly is really the worst pest [of live stock in Colorado] on account of its being so abundant and ever present." In northern Colorado and southern Wyoming, at altitudes of from 5,000 to 7,500 feet, the writer has observed the insect to annoy horses and cattle greatly during the latter part of summer. From a statement made by Prof. J. M. Aldrich we learn that it is troublesome to cattle in Idaho, and Prof. R. W. Doane states that it is one of the worst fly pests to live stock in California.

THE SEVERE OUTBREAK OF THE STABLE FLY IN 1912.

During the late summer and early fall of 1912 an unprecedented outbreak of this pest occurred in northern Texas. The area of greatest abundance was practically coextensive with regions where grain was extensively produced that season. The most severe injury was experienced in Grayson, Cook, Collin, and Denton Counties, in northern Texas. The fly was also abundant as far south as Hill County and as far west as Wichita County, and in parts of southern Oklahoma it also caused much alarm. In certain parts of Kansas and Nebraska it was also said to be more abundant than normal.

In Texas the flies appear to have become seriously numerous about August 12 and the outbreak to have continued in its severe form until the end of August. Flies were, however, very numerous throughout September and the greater part of October, but rapidly diminished after cold weather began. Under a number of the succeeding topics reference is made to conditions which prevailed during this outbreak. Some of these illustrate the severity of the pest during such an occurrence.

A study of the conditions existing in northern Texas during 1912 showed that the flies were breeding to a great extent in straw stacks. Unusually heavy rains occurred in the early part of August, and as most of the straw was freshly threshed and had not become settled, the rain deeply penetrated the stacks. The straw became heated immediately and formed very attractive breeding places for flies. The grain crop of 1912 was one of the largest ever produced in Texas, and as the straw was also heavy a great number of straw stacks were present to furnish their quota of the pest. In fact, the flies were so numerous around these stacks that many men in plowing their fields avoided, so far as possible, the portions adjacent to them. Although the stacks dried out rapidly on the surface, the straw beneath continued moist for several months, and flies continued to emerge from these stacks where the straw was not destroyed or where breeding was not otherwise prevented.

Dr. L. O. Howard published a note a few years ago calling attention to a report by Prof. Iches on an invasion by this fly of a large estate in the Province of Santa Fe, Argentina. This occurrence appears to have been very similar to the recent outbreak in Texas. The flies were found by Prof. Iches to be breeding in wheat and flax straw after threshing.

HOSTS.

Practically all warm-blooded animals are attacked by this insect. Some of our domestic species, however, are much freer from injury than are others, owing to protection afforded the host by its hair or by some habit. Mules in general seem to be more annoyed by the flies than any of the other domestic live stock. Horses and cattle are, however, heavily attacked and often suffer severe injury. Those animals which are not easily disturbed and irritated act as hosts for a greater number of flies, but the result is probably not so serious as with more nervous individuals, which are consequently more easily worried. Sheep and goats are attacked on parts of the body not protected by wool, particularly the legs. Hogs are often attacked, especially when they are free in pastures. The flies are not attracted to the hog pens as are house flies, and where the animals have access to mud they are seldom bitten to any great extent except when flies are extremely abundant. Dogs and cats have also been seen with flies feeding upon them. Dogs with thin hair are exceedingly susceptible to injury and are greatly worried by the attacks. In some cases the flies become sufficiently numerous, especially on the ears, where they are inclined to feed most commonly, to cause the blood to trickle from the bites. In a few instances chickens have been seen with flies feeding upon their combs; however, healthy poultry are so active, as well as so largely protected, that they are seldom annoyed. Man is also frequently attacked by this pest, although the attack is usually quickly discovered on account of the pain caused by the insertion of the beak. During severe outbreaks men engaged in field work are often greatly annoyed by the flies, which not only attack exposed portions of the body but are able to bite through shirts or other comparatively thin garments as well. The flies also frequently attack the ankles of people, especially when low shoes are worn.

CHARACTER OF INJURY AND LOSSES.

As has been indicated, this fly is of importance in a number of ways. There is little doubt that it is a potent factor in disease transmission, although it has been definitely proven to carry only a few diseases. Among live stock there is no doubt that the tropical disease of camels, horses, and cattle known as surra is transmitted by this insect. This disease fortunately does not occur in this country, but unless great care is exercised in importing stock it may be introduced at any time. Another related disease of cattle, horses, and sheep, known as souma, and still another malady of hogs and cats are carried, at least in part, by this same insect. In this country anthrax in domestic animals and man is also probably disseminated to some extent by this fly. Some investigators also consider it to be an agent in transmission of septicemia in man and glanders in horses and other animals, and the disease known as infectious æenemia or swamp fever of horses is thought by some to be carried by this pest. A number of years ago it was found to act as an intermediate host for a species of roundworm which infests cattle. Thus it will be seen that the transmission of a formidable array of diseases is chargeable to this one species of biting fly.

Aside from its importance as a disease conveyor this insect is of much importance on account of the worry produced by its bites. During severe outbreaks this is probably the most important factor in bringing about losses. During periods of great abundance all live stock are compelled to keep up a constant fight against flies from early morning until dark. At such times the flies are not only present around barns but in towns and cities and open fields. Animals which are being worked in the streets or kept in stables suffer alike. During the severe outbreak which occurred in 1912 many horses and cattle became so weak that they gave up the fight against the pest and the flies swarmed over them in countless numbers. In a few of these cases, where the animals were not promptly protected from attack, they succumbed in a short time. The loss of blood during severe outbreaks is a very important consideration. When fully engorged the abdomen of the fly is greatly distended, and it has been found that the blood extracted at one feeding is soon digested and the fly is ready for another meal. Thus animals continually exposed must serve to engorge thousands of individuals each day, each of the flies ingesting several drops of blood during a meal.

In the portion of the United States where Texas fever occurs, in addition to the live stock actually killed by worriment and loss of blood, a considerable number of cattle are lost from Texas fever. In most of these animals, although the disease organisms are latent in the blood, no apparent injury would result under conditions favorable to live stock. Under the strain of continually fighting the flies and with the weakened condition brought about by the loss of blood, however, an acute form of Texas fever is induced. When animals begin to suffer from the fever they are less energetic in fighting the flies and consequently become the more ready victims. During the outbreak in 1912 acute Texas fever was certainly produced as a result of fly attack. Owing to the continual biting of the insect the fever could not be reduced in many cases and the animals speedily died.

During severe outbreaks the loss brought about by the reduction of the milk supply in fly-infested zones is an important item. In the 1912 outbreak many dairymen found that their output of milk was reduced from 40 to 60 per cent, and that in some cases cows were completely dried up. For several months after the pest had abated, the effects of the outbreak were apparent in the reduced milk production. Even in cows which freshened several months after the pest had abated, the effect on milk yield was said to be still apparent.

During 1912 all animals in the fly zone were greatly reduced in flesh. Cattle which were fat enough for market in many cases were so much reduced that they could not be sold. Horses and mules in many cases lost from 10 to 15 per cent in weight during the outbreak. Some dairy herds which were usually shown at the State fair suffered such marked injury that they were not fit for exhibit.

In many cases the joints of both horses and cattle became so swollen and stiff, from standing in water where they sought protection from flies, that they could scarcely walk. The incessant stamping of the animals also had the effect of injuring the feet and joints. A number of liverymen found it necessary to discontinue making drives into the country, and some of their animals were completely disabled for regular work.

Another source of loss to farmers was their inability to proceed with their usual farm plowing and other operations at the proper time. In many sections the flies were so bad on the horses that they could not stand both the work and flies. Some men resorted to night work as a means of escaping the attack, but this was too severe for the teams, as the flies allowed them no rest during the day. Numerous instances of horses becoming frantic from irritation were recorded; these often resulted in runaways and consequent destruction. Animals which were not being worked sometimes received injuries from running into barbed wire fences in endeavoring to escape the flies.

The total loss due to the outbreak in 1912 is difficult to estimate. It is believed that in northern Texas over 300 head of cattle, mules, and horses were killed directly or indirectly as the result of the fly attack. This actual death loss may be conservatively placed at $15,000. The loss due to the reduction in milk supply may reasonably be placed at $10,000, and other losses far surpass these two items. Moreover, these were the losses experienced only in the few counties in northern Texas where the fly was most abundant and does not include the more or less serious injury sustained in practically all parts of the United States.

ACTION OF ANIMALS ATTACKED.

All animals are usually greatly annoyed by the attack of this fly. Less nervous individuals sometimes permit the flies to feed without particular effort to drive them away, while others of more nervous temperament are driven almost frantic by the attack. In general, mules seem to be worried rather more than horses, and most cattle are less irritated than either mules or horses. Sheep and goats are much annoyed by the presence of the insect, but because they are largely protected by the wool they are able to keep the flies off their legs by frequently moving them. A great difference in the degree of annoyance produced among dogs has been noticed. Some individuals are greatly irritated by the presence of a single fly and frequently change their positions, going from one place to another to seek protection. Horses and mules that are being driven sometimes pay little attention to flies, while in other cases they may lie down and roll or even run away in their frantic efforts to escape. During times of unusual fly abundance animals, when free in pastures, frequently bunch up on knolls where they are exposed to the wind and apparently secure some protection by contact and concerted fighting. When streams or pools of water are accessible both horses and cattle, particularly the latter, take to them for protection. Cows often lie down in the water so as to be almost completely covered, and the coating of mud obtained in such situations offers some protection from fly attack. Stock often temporarily rid themselves of most of their annoyers by running through trees and brush. If permitted to reach stables or barns, the animals usually crowd within and remain inside throughout the day. During the severe outbreak in 1912 it was almost impossible to get some animals to leave the stables and go into pastures, even after nightfall, on account of their fear of the flies. Although the bunching of the horses in the stable affords some protection, yet this by no means exempts them from fly injury, as the pest is often as bad within such places as without. Sheep and hogs exhibit similar habits in endeavoring to secure protection; they often lie in close groups in shady places and keep their heads and legs protected by placing them against or beneath one another. When mudholes are accessible, hogs largely escape the flies by lying in the water and becoming covered with mud.

It is possible to determine, even at considerable distances, by watching the actions of the animals, whether the stable fly or horn fly is bothering cattle. When the stable fly is present the continual stamping of the feet and striking at the legs with the head and tail indicate the point of attack, while when the horn fly is present the animals pay particular attention to the back and sides. The bite of the stable fly is evidently much more severe than that of the horn fly, as it causes very great annoyance even when the flies are present in much fewer numbers.

SUMMARY OF LIFE HISTORY.

Like all other flies, this species has four stages in its life history, namely, the egg, larva, pupa, and adult.

The egg.—The eggs of this fly are elongate ovoid and of a creamy white color. They are about one twenty-fifth of an inch in length and under a magnifying glass show a distinct furrow along one side. When placed on any moist substance they hatch in from one to three days after being deposited. In hatching a small slit is made around one end of the groove, and the minute maggot crawls out. Figure 1 shows four eggs on a piece of straw; the two at the right have hatched.

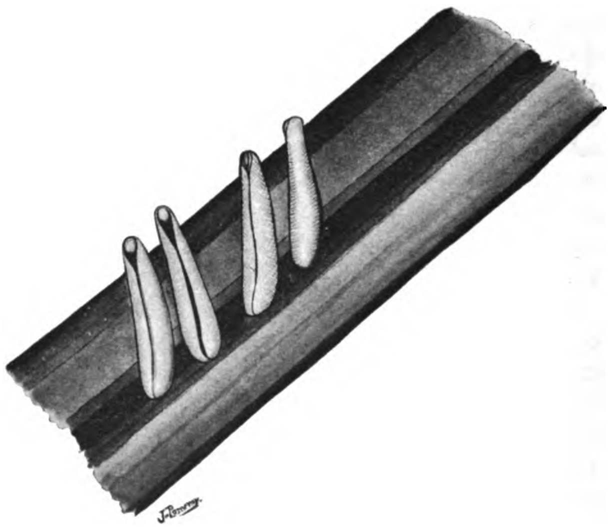

FIG. 1.—Eggs of the stable fly (*Stomoxys calcitrans*) attached to a straw. Greatly enlarged. (Original).

The larva, or maggot.—When first hatched the larvæ, or maggots, are about one-twelfth of an inch in length and, being translucent, are not easily seen with the naked eye. Development takes place fairly rapidly when the proper food conditions are available, and the growth is completed within eleven to thirty or more days. When full grown the larvæ (fig. 2) are pale yellow or nearly white and about four-fifths of an inch in length. They have the typical shape and action of most maggots of this group of flies. The hind end is large and the body tapers to the head. The larva moves quite rapidly by means of minute projections on the edge of each segment along its underside. When exposed to the light it quickly disappears again in the straw or other matter in which it is breeding.

The pupa.—When the larvæ are full grown they shorten and become thicker, and the skin contracts and hardens to form the case in which the transformation to the adult is to take place. This puparium, or pupal case, is rather soft and yellowish at first but soon becomes harder and changes to a reddish brown color. It is elongate oval, slightly thicker toward the head end, and from one-sixth to one-fourth of an inch in length (fig. 3). During this stage the insect is completely dormant, the transformation from maggot to adult fly going on within the puparium. This resting stage requires from six to twenty days, or in cool weather considerably longer.

The adult.—When the fly has completed its development within the puparium it pushes its head against the end until the shell splits open. It then crawls out as an adult fly but so different from the fly ordinarily seen that one would scarcely recognize it. The color is pale and the head considerably produced in front between the eyes. At this time the wings are only small, wrinkled sacs. In a few minutes air is forced into the wings, and they slowly unfold, the fly becomes gradually darker in color, and its body becomes harder. Up to this time the beak is not visible, as it is bent downward between the legs. It soon becomes almost black and is brought forward in its natural position so that the tip may be seen from above. When completely dried out the adults show four rather distinct, dark, longitudinal markings on the thorax, as well as several dark spots on the abdomen. The male is usually slightly smaller than the female, the body of which measures from one-fourth to five-sixteenths of an inch in length. The adult, as seen from above, is shown in figure 4, and a side view of a female specimen engorged with blood is shown in figure 5.

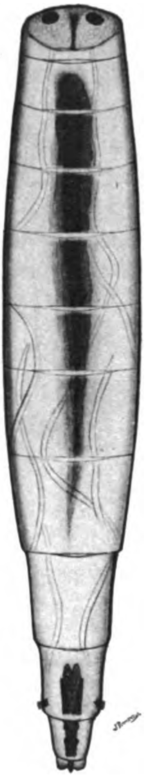
FIG. 2.—The stable fly: Larva or maggot. Greatly enlarged. (Original.)

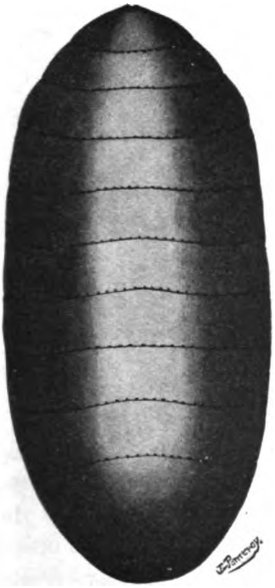
FIG. 3.—The stable fly: Pupa. Greatly enlarged. (Original.)

This insect is closely related to the house fly, as can be readily seen by its close resemblance to that insect. It may be distinguished from the house fly, however, by the long, sharp, biting mouth parts, a portion of which may be seen projecting forward from beneath the head. The proboscis of the house fly is short and broad and not capable of piercing. The stable fly is usually slightly stouter than the house fly, and the spots on the abdomen also aid in distinguishing it from that species.

The horn fly is also related to this species but is of much smaller size, and the color is considerably different. When on a host these flies may be readily differentiated by the attitudes they assume. The stable fly usually attacks the lower portions of the legs of its host and nearly always sits with the head up. The horn fly is more inclined to feed on the back and sides of the animal and always feeds with the head downward, while the house fly may be seen sitting in any position but never with its head pressed into the hair as though feeding.

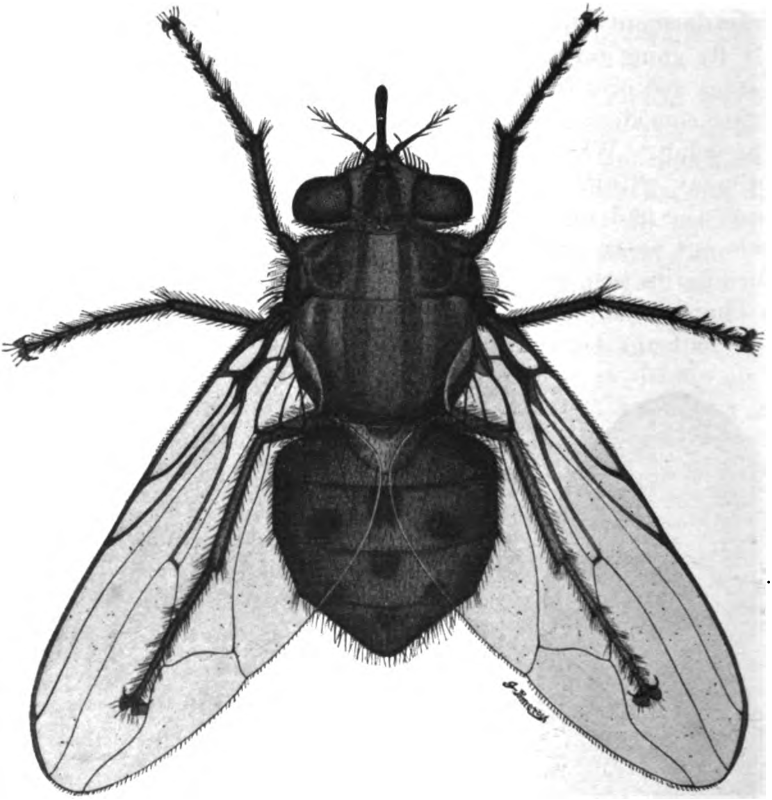

FIG. 4.—The stable fly: Adult female as seen from above. Greatly enlarged. (Original.)

DEVELOPMENT AND HABITS.

BREEDING PLACES.

Horse manure has long been considered the normal breeding medium for this pest. Investigations made during the outbreak in 1912 showed clearly, however, that the vast majority of the flies bred out in straw stacks, and investigations made around stables and barns indicate that while the fly breeds in pure horse manure it favors a mixture of this substance with straw. The fly was found to be breeding in much greater abundance in oat straw than in wheat straw. This appeared to be due to the softer stems and the greater amount of leaves in the oat straw, which furnished better food and allowed the stacks to become more compact. Rice straw was also found to furnish suitable breeding conditions, and there is little doubt that barley and rye also often serve as food for the immature stages.

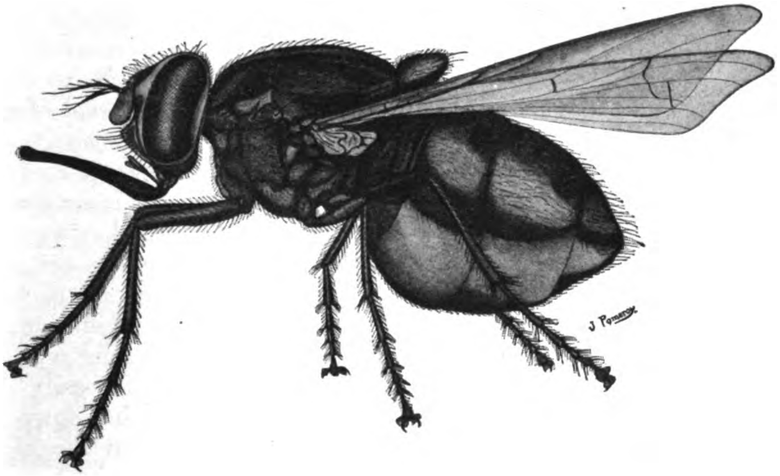

FIG. 5.—The stable fly: Adult female, side view, engorged with blood. Greatly enlarged. (Original.)

As has been stated, it was found by Prof. Iches to breed in great numbers in the débris left after thrashing flax. A careful examination of portions of alfalfa stacks which were moist and readily accessible to numbers of flies showed that they were not infested. This was also found to be true of accumulations of weeds and bunches of grass in open fields. It is probable, however, that the insect may occasionally breed in broken-up masses of hay or dead grass, especially when they are permeated with liquids from manure. The manure piles commonly found by stables where horses are kept furnish suitable breeding conditions. This is especially true in the early spring, when the warmth of the manure appears to be very attractive to the flies for egg laying. Cow-lot manure which has become broken up, especially when mixed with waste feed, is also utilized as a breeding place for the insect. This has also been found to be true of ensilage, particularly when mixed with straw, as is often the case when the bottom of a silo is cleaned out. Experimentally, a few specimens have been reared from pure cow manure, but this substance seems to be unattractive to the adult and not favorable for the breeding of the larvæ on account of its very compact texture. A Russian investigator, Prof. Portchinski, has made the statement that the larvæ have been found in the leaves of growing plants. This, however, must be a very rare occurrence. This species has never been found breeding in human excrement and does not frequent malodorous places, which are so attractive to the house fly. Hence it is much less likely to carry typhoid and other germs which may be found in such places.

The development of this insect is somewhat slower than that of the house fly, and it is therefore more essential, in order that it may breed out successfully, that the eggs be deposited in rather large accumulations of material. The larvæ are very sensitive to drought and soon succumb if the material in which they are breeding is not kept rather moist.

HABITS OF THE ADULT.

Both the male and female of this species feed on the blood of animals. They appear to discover their host mainly by sight and usually, especially on cattle, pass quickly to the lower portion of the legs (fig. 6), particularly on the outside, where the hair is somewhat shorter than on other parts of the animal and where they are less likely to be struck by the tail of the host. When the flies are very abundant their attack is by no means confined to the legs, as both cattle and horses have been seen practically covered with flies on all parts of the body. They seldom remain on the host long without inserting the beak. Before blood is extracted they are easily disturbed and often move about several times before settling down for final engorgement. After the beak is well inserted and the blood begins to flow they usually become engorged in from two to five minutes. During feeding the abdomen becomes greatly distended (see fig. 5) and often of a distinctly reddish color. When the appetite of the fly has been satisfied it withdraws its beak and flies rather sluggishly to some near-by object, where it rests while digesting its meal. During this process numerous drops of clear liquid excrement are voided. This also takes place while the fly is feeding. The insertion of the beak is accompanied by a rather severe, sharp pain. This accounts for much of the worriment caused to the host by this species. After blood extraction has begun little or no pain is felt. When the proboscis is withdrawn a drop of blood usually exudes from the wound. Numerous small flies have been seen to frequent the blood which exudes in this way, and it is not improbable that the screw-worm fly may deposit its eggs on these spots and thus cause infestation of the host with these maggots.

During warm weather the blood is digested rapidly and the flies may feed again the same day. When the weather is cooler they usually require about a day for the digestion of the blood. After partaking of a meal the flies, during hot weather, ordinarily alight on the walls of buildings or on foliage of plants in shady situations. When the temperature is lower they remain in the sunlight, but in all cases they tend to avoid strong wind.

Adults frequently follow for considerable distances teams traversing roads and, when engorged, settle on near-by objects. Other teams which pass along the same highways are thus frequently attacked by flies which have completed the digestion of their previous meal, and this has given rise to the idea that the flies are breeding in weeds, grass, and hedges along the highways. This is also a means by which the flies invade territory beyond that in which they develop. Adults have also been observed to travel many miles in the passenger coaches of railways. Few individuals are carried in this way, but doubtless the spread of the species is aided and, what is more important, diseases might be spread in this way by infected flies.

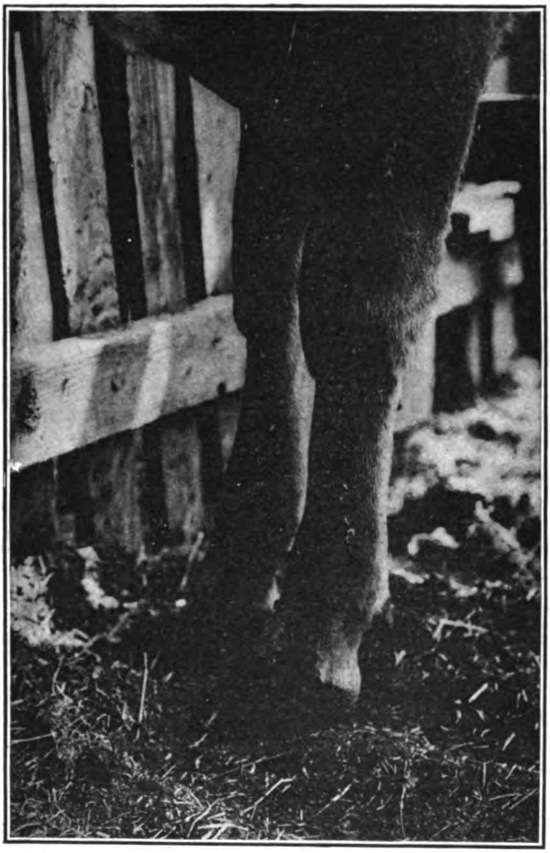

FIG. 6.—Legs of a steer attacked by the stable fly. (Author's illustration.)

Feeding may take place a number of times. Experimentally, individual flies have been induced to engorge as many as 14 times. Flies have been observed to partake of water and to feed to some extent on succulent fruit. They commonly feed on the moisture on fresh manure and on rotting straw. Although man is occasionally bitten by these flies, horses and cattle seem to be preferred as hosts.

REPRODUCTION.

Mating of the flies takes place while they are not on hosts, and egg laying soon follows, provided the flies have fed a sufficient number of times. It seems that at least three feedings on blood are necessary for the production of eggs. After the third meal is digested the flies seek suitable places for deposition. When the weather is cool additional feedings are often necessary before eggs are produced. The adults appear to have a keen sense of smell and are able to detect moist straw and suitable manure very quickly. This is especially noticeable when a straw stack which is dry on the outside is opened up so as to expose the moist and rotting interior.

Very soon after a stack is opened flies are seen to come to the moist straw in numbers and begin depositing eggs. They usually crawl into the loose straw, sometimes going to a depth of several inches. When laying eggs the fly greatly extends the ovipositor and uses it as an organ of touch in locating a suitable spot in which to deposit. The eggs are laid in irregular masses, although occasionally single ones are deposited. The female usually moves several times during deposition so that each mass contains from a few to as many as 25 or more eggs. The greatest number of eggs which has been observed to be deposited before another meal of blood is taken is 122. After all of the eggs have been deposited the female again seeks a host, and this feeding is again followed by deposition. Three of such depositions commonly take place in this species. It is sometimes necessary, especially during cool weather, for a fly to become engorged twice before each deposition following the first. The greatest number of eggs which has been seen to be deposited by a single female during her life is 278.

LENGTH OF LIFE OF THE ADULT.

A considerable number of experiments have been made to determine the length of life of the adult fly. A knowledge of the longevity of the adult is important in order that its possibilities as a pest may be determined and that we may ascertain whether the species may act as a true host of disease organisms; that is, whether disease germs can multiply within the fly before being capable of producing the disease in a higher animal. Individuals kept in small tubes without food or water during hot weather died within two days. When water and sugar sirup were supplied to flies, in a screen cage about 1 foot square, one specimen out of a large number of males and females lived for 23 days. Individuals which had access to blood at frequent intervals lived 17 days, and a few specimens, among a considerable number which were kept in large cages with cattle and suitable material in which to deposit eggs, lived for 29 days. When flies had been supplied with fruit and moist straw, but had not had access to host animals, they frequently lived for 10 days.

THE LARVA AND ITS HABITS.

The larvæ begin feeding as soon as they hatch from the eggs and continue to do so throughout their growth. Portions of moist straw or other material in which they are breeding are torn off by their mandibles, which are located on the narrow or head end of the maggot. When very small they frequently penetrate between the layers of the stalk or leaves of grain when moistened in the straw stack. When larger they frequently feed within the straws, and transformation to the resting state sometimes takes place in this protected situation.

The duration of the larval stage has been found to vary from 11 to 30 days. During very cold weather this stage is probably considerably longer than one month. The character and abundance of food as well as the amount of moisture present have an important influence on the development of the maggots. The larvæ follow the moisture inward as the material in which they are breeding becomes dry on the surface. Pupation occurs anywhere in the breeding material; however, it frequently happens that the larvæ, when breeding in small masses of straw or manure, work downward as the material dries and pupate at the surface of the soil.

LIFE CYCLE.

It has been found that the complete development from the deposition of the egg to the emergence of the adult fly may be completed in 19 days. On the average the period is somewhat longer than this, generally ranging from 21 to 25 days where conditions are very favorable. The longest period observed for complete development was 43 days, although it is certain that in the late fall and during the winter months a much longer period is often necessary. The finding of full-grown larvæ and pupæ in straw during the latter part of March, 1913, in northern Texas shows that development may require about three months, as these stages almost certainly developed from eggs deposited the previous December.

SEASONAL HISTORY.

The stable fly is particularly abundant and injurious in the late summer and fall. This is especially true in the Northern States, where development begins later in the spring. Mr. C. T. Brues states that the flies first appear in noticeable numbers about June 1, in the vicinity of Boston, Mass. The fly has been observed to be sufficiently numerous to annoy cattle considerably at Dallas, Tex., as early as March 1, and in the western part of Texas it has been observed feeding on live stock in considerable numbers early in May. At Batesburg, S. C., Mr. E. A. McGregor found the adults to be commonly attacking live stock about the middle of March in 1913. In the extreme southern part of the United States, however, there is no month during the year in which flies are not annoying to horses and cattle.

The number of generations of this insect annually has not been determined, but it is estimated that seven broods may readily develop in one year in the Southern States. In the Northern States probably five broods is about the usual number.

HIBERNATION.

In the southern part of the United States there is no true hibernation of this insect. The adults have been found to emerge at various times throughout the winter, and during warm periods at Dallas, Tex., they have been observed to feed on animals. Mr. W. V. King reports that considerable numbers of adults were present throughout the winter of 1912–13 at New Orleans, La. In fact, they appeared to be even more numerous in midwinter than during the previous fall. At Victoria, Tex., Mr. J. D. Mitchell found them to annoy stock throughout the winter. Although no egg laying appeared to take place during the winter of 1912–13 at Dallas, Tex., it may sometimes occur at that latitude and probably occurs throughout the winter in the extreme southern part of the United States. It would seem that most of the individuals which pass the winter successfully hatch from the eggs laid in the fall and continue development slowly during winter, emerging in early spring when conditions are favorable for further reproduction. Examinations of straw stacks in northern Texas, made during the latter part of March, 1913, showed a few full-grown larvæ and large numbers of puparia. These almost certainly developed from eggs deposited the previous December. In the northern part of the United States it is doubtful if many flies emerge during the winter months, the winter being normally passed in the larval and pupal stages. Near Boston, Mass., Mr. C. T. Brues observed adults to be active in heated stables in the dead of winter. These individuals probably bred out in refuse within the warm barns and were not hibernating adults. In 1913, at Clarksville, Tenn., Mr. D. C. Parman found that the adults began emerging about March 30.

AGRICULTURAL PRACTICES IN RELATION TO FLY ABUNDANCE.

A number of agricultural practices which are commonly in vogue in the United States are calculated to favor greatly the development of this species. As has been stated, this species breeds most commonly in straw and horse manure or a mixture of these two substances. The usual custom of allowing the manure from the horse stable to accumulate just outside of the stable doors absolutely insures the presence of a considerable number of stable flies at all times when climatic conditions are suitable for breeding. Allowing barnyards, especially around dairies, to become knee-deep in manure is also calculated to produce flies in abundance.

In the grain belt it is the general practice for farmers to thrash the grain in the fields by means of self-stacking thrashing machines. The individual stacks cover much ground and the straw is very loosely piled. In many cases for convenience a large number of stacks are formed in various parts of a field. This condition, when followed by more or less heavy summer and fall rains, is certain to produce great numbers of flies. In fact, this is precisely the condition which occurred in 1905 and in 1912, when the serious outbreaks of the fly occurred in Texas. In many instances straw stacks are not protected from live stock. The animals soon scatter the straw about and by adding manure to the straw still further favor the breeding of flies. These straw stacks are usually allowed to remain from one year to the next without any attention whatever. When the succeeding crop is planted the area occupied by the stacks is simply left uncultivated. In a number of instances 50,000 square feet have been found occupied by a single stack, and in many cases several of these stacks occurred in a field of 60 or more acres. A railroad official recently computed that the area covered by wheat stacks in Kansas alone is no less than one-fourth of a million acres. Such stacks are usually allowed to remain throughout the fall and winter and in a few cases are burned the following spring. More frequently, however, they are left from year to year and the new straw added to the old stacks, destruction only taking place when the stacks become exceedingly large. It will be seen that these practices not only encourage the breeding of the stable fly, but when the straw becomes sufficiently rotten and compact the house fly as well breeds in it in abundance. Throughout the grain belt a very considerable amount of valuable land is untilled and the full manurial value of the straw is lost. Of course the stacks serve some purpose as shelter and food for live stock kept in the fields during winter. In fact, this is the only legitimate reason for not scattering them or burning them in the late summer or fall.

NATURAL CONTROL.

CLIMATIC EFFECT.

The adults feed when the temperature is very high and the sun bright and hot as well as during cool and cloudy weather. They have also been observed to attack animals during drizzling rain, and when somewhat protected by sheds and stables they often feed during heavy rain. The lowest temperature at which flies have been observed to partake of blood was 55° F. When the temperature goes below 60° F. their desire to feed is less marked. Between 40° and 48° F. they lose their ability to fly, and complete inactivity occurs when the temperature ranges between 31° and 45° F. This range of activity is due to variation in individual flies, to the rapidity of the decline or rise in temperature, and to the minimum temperature experienced by the individuals. No adults appear to be killed when the temperature does not go below 27° F., and some at least are able to survive temperatures considerably below this point. All of the adults at Dallas, Tex., seem to have been killed when the temperature reached 8° F. As has been stated, the flies always seek shady places during hot weather, but when the temperatures are low they delight to dart about in the sun in a manner very similar to that of the house fly.

The maggots, or larvæ, are very susceptible to drying. This is particularly true soon after they are hatched. Excessive moisture is also detrimental to their development, and flooding kills them in a few hours. They appear to be able to endure rather high temperatures when abundant moisture is at hand, although the heat produced in manure and straw stacks is often sufficient either to kill them or to drive them outward. No doubt the generation of heat within the breeding places stimulates the development of the immature stages during the fall and winter months. Light is detrimental to the development of the larvæ. When placed in bright daylight, even though sheltered from the sun, larvæ have never been known to complete development. These facts make it possible successfully to destroy the pest in this stage of its life.

The pupæ of the insect, being in the resting stage, are much less susceptible to all climatic extremes. They appear to be able to withstand low temperatures and are not very susceptible to heat or drying, especially after development of the fly has proceeded for some time.

PREDACEOUS ENEMIES.

Hogs, as well as chickens and other poultry, are capable of destroying great numbers of the immature stages of the stable fly. They are attracted to the straw stacks and manure piles partly by the grain to be found, but incidentally they destroy the maggots and pupæ which they find. A number of insects are also important destroyers of these stages. Certain beetles devour them in considerable numbers. The adult flies fall prey to numerous enemies. Among the more important enemies of the adults are the large robber flies, which may be seen in great numbers around straw stacks, pouncing upon flies which are depositing eggs or resting upon straw. A number of wasps capture the flies that are attacking stock or flying about. When filled with blood the adults are comparatively sluggish and much more easily caught by these enemies. When in this condition spiders often devour numbers of them.

PARASITES.

Two species of small wasplike insects have been found to breed within the pupæ of the stable fly. These insects deposit their eggs through the hard puparium, and instead of an adult fly the little parasite emerges. In some cases, where the immature stages of the fly were concentrated in great numbers, as high as 40 per cent of the pupæ were found to be destroyed by these parasites. At least one of these parasites, known scientifically as *Spalangia muscidarium* Richardson, appears to have a wide distribution in this country. It has been found in Massachusetts, Washington, D. C., southern Kansas, southern Louisiana, and a number of points in northern Texas.

ARTIFICIAL CONTROL.

As is the case with most insects, the destruction of the stage which is actually doing the injury is most desired by those concerned. With this species, as with many others, this is very difficult of accomplishment, and we must determine some more easy way of securing the desired end. With the stable fly the natural point of attack is found in the immature stages, and there is every reason to believe that by properly caring for substances in which it breeds the insect may be kept well under control.

PROTECTION OF LIVE STOCK FROM ATTACK OF THE STABLE FLY.

When adult flies are present in great numbers it is necessary to devise some means of protection against them, especially since we know that every individual is capable of feeding a number of times before it dies. During the recent outbreak in Texas many different substances were tried with a view to repelling the flies from live stock. Most of the materials used were found to be ineffective, and although some gave a measure of protection for a time, none had a lasting effect. In addition to the temporary value of these substances, in many cases injury was produced by their application, especially if persisted in often enough to keep the flies away.

Many malodorous mixtures, particularly of an oily nature, have some value as repellents, but in preparing these care should be taken that they are not made too strong, particularly when animals are being worked in the hot sun, as they are likely to cause overheating and often produce shedding of the hair. A mixture of fish oil (1 gallon), oil of pine tar (2 ounces), oil of pennyroyal (2 ounces), and kerosene (½ pint) was found to be very effective in keeping the flies off live stock when applied lightly, but thoroughly, to the portions of animals not covered with blankets or nets.

Work animals may be largely protected from the pest by means of coverings. One type which was found very effective and inexpensive during the recent outbreak in Texas consisted of a blanket made of double thickness of burlap so arranged as completely to cover the back, sides, and neck of the animal (fig. 7). The legs are then covered by means of old trousers slipped on over the feet and tied over the back. Leather nets or strips of leather attached to the bridle also aid in keeping the flies from the head. The ordinary flynet has been found to be of little value as it only tends to displace the flies temporarily and cause them to settle in places not covered by the net.

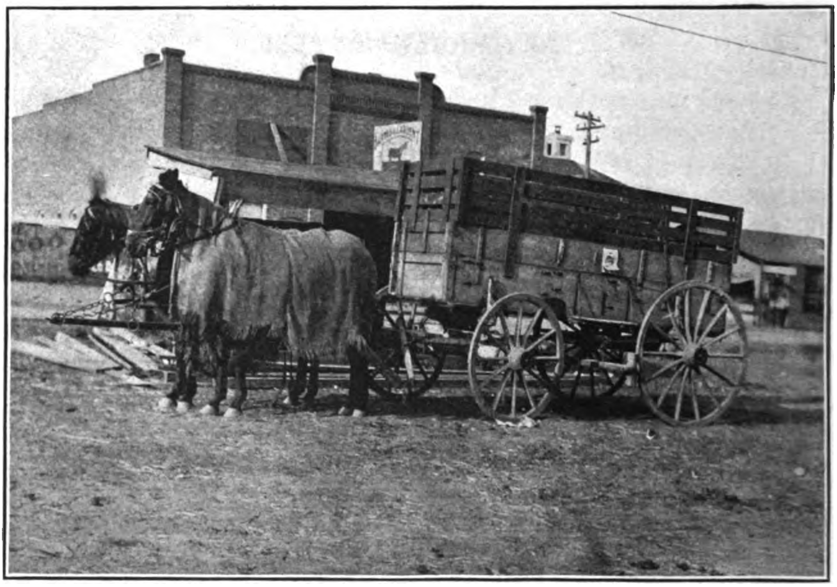

FIG. 7.—Horses with one form of covering used to protect them from the stable fly. (After Felt.)

Completely darkened stables offer much protection from the flies. The lack of ventilation resulting from such an arrangement is very objectionable, however. The thorough screening of all windows and doors is, therefore, much more desirable. When screened barns are used care should be taken to brush the flies from the animals, when they are about to enter, by means of nets over the doorway, or with sacks. Little can be done to protect range stock from the flies. On hog farms a freshly plowed trench offers considerable protection to the swine. The sides of these trenches may be smeared with petroleum which is rubbed off on the animals and acts as a repellent. The trench may be used also for protecting sheep; but the petroleum in their case is unnecessary.

TRAPPING THE FLIES.

It is impossible successfully to capture adult flies by means of the traps ordinarily used for the house fly. However, a trap has been designed by Prof. C. F. Hodge which may be utilized in capturing adults as they enter or leave barns. This trap is undoubtedly very effective under certain conditions and has the advantage of catching not only the stable fly but the house fly and other obnoxious species. In order to employ the trap for the stable fly it should be built in a frame so as to fit closely in a window, preferably on the brightest side of the barn and close to the cows or horses which are kept within. Other windows should be darkened by hanging gunny sacks over them. This may be done so as not to interfere with ventilation, and by flapping in the wind and darkening, both drive and cause the flies to be attracted to the light trap-window.

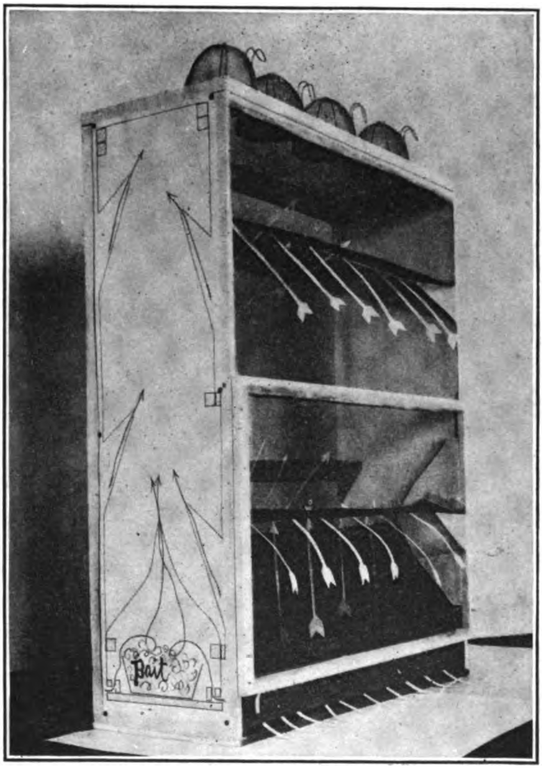

Fig. 8.—The Hodge flytrap, showing where the flies enter. (After Hodge.)

Prof. Hodge has very kindly permitted the use of some of his illustrations of this trap (figs. 8, 9, 10), and his description of its construction has also been followed. At the bottom of the trap a space about one-fourth of an inch wide running entirely across the window is left on both sides of the frame. This crack admits the flies beneath a roof or ridge of screen wire having holes large enough for flies to go through punched along its top at 2-inch intervals. In order to capture the house fly, bait consisting of any material which is attractive to them is placed in pans beneath this ridge. The flies enter this space and then ascend through the holes and are unable to escape. The sides of the trap, also, are made of ordinary screen wire bent inward and upward in two horizontal folds running across the window, one toward the bottom and one toward the top. The ends of the screen are then securely tacked and a series of small holes punched along the inner edge of each of the folds. The trap-folds and ridge must not be too sharp or flies will not go up to the angle. They should not be less than 45°. The flies, in trying to go in and out through the window, crawl into the folds and enter the holes at the apex, but never escape, as on the inside the holes are along the projecting ridge. Prof. Hodge states that a trap set in a window in a basement barn near a cow within caught nearly 5 quarts of flies from July 1 to November 1. The stable fly constituted 90 per cent of these flies, this being practically all that appeared on the place.

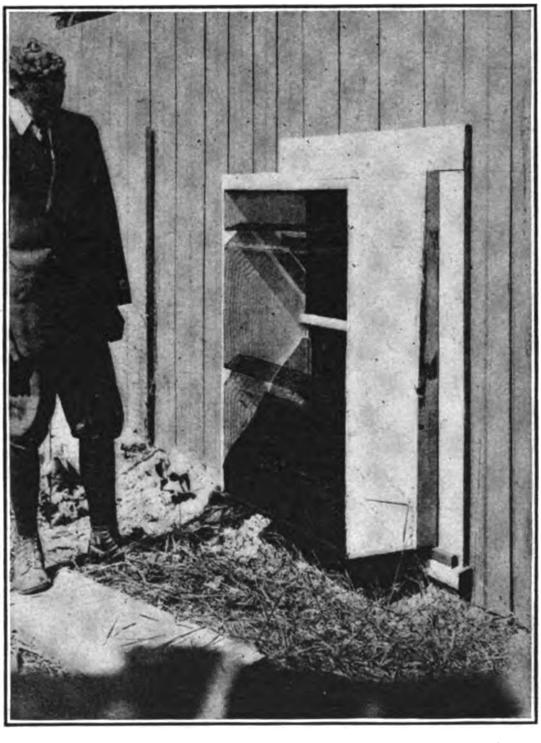

FIG. 9.—The Hodge flytrap fitted to a barn window. (After Hodge.)

This trap is inexpensive and can be made by anyone with a box, or box lumber, and screen wire. It is especially well adapted to well-made barns where the flies do not have numerous places for entrance and exit. It is also more applicable to small barns in which animals are kept more or less constantly than to large dairy barns where the cows are brought in only at milking time. Under the latter conditions the flies enter the barns on the cows and many remain on the walls of the barn until after the cattle have been turned out. In some cases where flies are concentrated in dairy barns in this manner they have been driven out by forcing live steam into the building from the boilers used for sterilizing purposes. Where such arrangements are made the flies may be caught in such traps as the one described, as they are endeavoring to escape from the barn, which should first be tightly closed.

If such barns are tightly closed, as above, during the light part of each day, the flies will practically all "catch themselves" in trying to escape through the trap-window or windows.

DESTRUCTION OF IMMATURE STAGES AND PREVENTION OF BREEDING.

Since straw stacks have been found to be the principal breeding places of this insect in the grain belt, the proper care of the straw is by far the most important step in control. The straw should be stacked more carefully than is ordinarily done, when it is desired to keep it for protection and food for live stock. This may be accomplished by making the sides of the stack nearly vertical and rounding it up well on top, in order the better to shed the rain.

So far as possible, all straw which is not required for winter feed for stock should be disposed of immediately by burning, or by scattering it over the land soon after thrashing and subsequently plowing it under, or by burning the stacks. The plowing under of the straw is the most advisable method of procedure, as by this practice large amounts of humus are added to the soil. Oat straw is most generally used for feeding purposes, and it is this straw which forms the principal breeding ground for flies. It is therefore important that all of the oat straw needed for feed or bedding be baled and stored under cover and that the remainder be promptly burned or scattered.

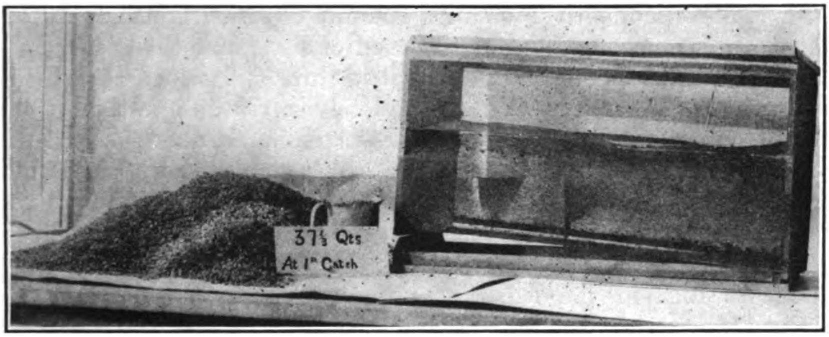

FIG. 10.—Pile of flies caught in a Hodge flytrap. (After Hodge.)

All straw stacks not consumed by stock during the winter should be promptly disposed of in the early spring, as these stacks furnish flies continuously during spring and summer. Often the flies reared in such situations are abundant enough to cause great annoyance to live stock during early spring, and by multiplying throughout the summer an almost incredible number of flies are produced by fall. An examination of an oat-straw stack at Gainesville, Tex., in March, 1913, showed a very large number of pupæ, from many of which flies were emerging. In portions of this stack it was estimated that 300 pupæ were present in each cubic foot of straw. This illustrates the importance of disposing, in spring, of straw which has been carried over the winter. Disposition of the stacks in spring may be accomplished in the same way as has been suggested to be followed in the fall.

The conditions which produced the unusual outbreak in 1912, that is, the heavy rainfall on the freshly thrashed straw, rendered the straw largely unfit for food for live stock, as the stacks in many cases were wet through and soon became heated and rotten. In such instances, where the flies are already breeding in these stacks, their immediate destruction by burning or scattering is necessary to relieve the conditions. When stacks are scattered the work should be done thoroughly, so as to expose the straw completely to the influence of the sun, wind, and light. By this procedure practically all of the larvæ and many of the pupæ are destroyed.

It is best to plow under the scattered straw soon after it has become well dried out. In many sections of the grain belt plowing is not generally practiced, the land being simply shallowly disked prior to seeding. The scattering of straw over the ground in such cases is less practicable than where the land is plowed. Of course, the practice of disking land is not a commendable one, and wherever plowing can be done it should be adopted.

In sections of the country where headers instead of binders are used, and consequently a smaller amount of straw is accumulated, the straw is much more easily disposed of by the methods just outlined. The general adoption of the field thrashers, which thrash the grain without cutting it, would completely solve the question of the straw stack. It is reported that this machine reduces the expense of harvesting from 14 cents to 2 cents per acre. The straw is left standing in the field and the chaff scattered over the ground, the entire refuse being turned under at plowing time.

The use of poisons or other substances, with a view of destroying immature flies in the substances in which they are breeding, is neither practicable nor advisable. Enormous quantities of these materials would be required to permeate the straw or manure piles to kill the flies, and, even though the flies were destroyed, the straw would be rendered dangerous to live stock.

Although straw is the principal breeding place for flies within the grain belt, there is no doubt that thousands of stable flies develop in manure piles. Moreover, such material is utilized extensively as a breeding place for the house fly and horn fly. Hence the proper care of all sorts of animal refuse is essential for successfully combating the pest. Manure should be hauled out and scattered at regular intervals, as is recommended for the control of the house fly, and any accumulations of straw or hay, especially adjacent to stables, should be disposed of, as these are often utilized for the breeding of the stable fly when larger accumulations of horse manure and straw are not available.

The need of properly caring for stable refuse is still further emphasized by the fact that there are far more manure piles than straw stacks. Furthermore, the stable manure is usually in close proximity to the habitations of man and thus furnishes flies which have freer access to man, with consequent greater potentiality as disseminators of human diseases.

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FARMERS' BULLETIN No. 541.

FARM BUTTER MAKING.

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U. S. Department of Agriculture,
Bureau of Animal Industry,
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Sir: I have the honor to transmit herewith for publication as a Farmers' Bulletin a paper on "Farm Butter Making," by Mr. J. R. Keithley, junior dairyman in the dairy division of this bureau. This paper is intended to replace Farmers' Bulletin 241, "Butter Making on the Farm," issued in 1905.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. D. F. Houston,
Secretary of Agriculture.

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FARM BUTTER MAKING.

The amount of farm butter, according to the census reports of 1890 and 1900, was in excess of 1,000,000,000 pounds annually. In 1909 it was 994,650,610 pounds. That a large part of this is of poor quality is generally known, but on account of the widely scattered, isolated condition of the farm butter makers it is a difficult problem to take steps which would result in an improvement. If this improvement is to take place and prove of profit to the farm butter makers it is very necessary that greater attention be given to details concerning the factors affecting the quality of butter.

The fundamental facts and practices concerning butter making should be applied by the farmer as well as the creamery operator. This knowledge and its importance should be known in order that it can be intelligently applied. Cleanliness and attention to details are the two prerequisites to the manufacture of good butter. The main defects in farm butter show these two prerequisites to be very frequently neglected. These defects are:

(1) Bad flavors.
(2) Lack of uniformity in color and salt.
(3) Unsuitable packages and no uniformity in the style of the packages.

The bad flavors are due largely or entirely to the changes in the milk and cream before it is churned rather than to the subsequent treatment of the butter.

CAUSE OF CHANGE IN MILK AND CREAM.

The change in milk and cream is due largely to the action of microorganisms known as bacteria upon the various constituents of milk.

Normal milk is composed of the following:

	Per cent.		Per cent.
Water	87.17	**Albumin**	0.53
Butter fat	3.69	**Sugar**	4.88
Casein	3.02	**Ash**	.71

The constituents which the bacteria act upon are the milk sugar, albumin, and casein. Their action upon the milk sugar results in the formation of a sour, acid by-product which causes what is generally known as sour or curdled milk. Their action upon the casein and albumin results in the formation of by-products of various peculiar flavors and aromas which may or may not be objectionable. The butter fat, which is affected only slightly, if at all, by the bacteria, very quickly absorbs any flavors or aromas which may result from the bacterial action upon the casein, albumin, or sugar.

The presence of bacteria in milk is dependent upon external conditions and agencies. Milk, when drawn from the udder of a healthy normal cow, contains bacteria in comparatively small numbers. Those which get in later must do so through the agency of some carrier, such as dust, dirt, filth, and manure from the atmosphere, hands and clothing of the milkers, or from the body of the cow. The exclusion of the most objectionable kinds of bacteria is simply a matter of cleanliness about the barn, milk room, or any other place where milk is handled and requires that attention be given to details. The bacteria, however, which do get into milk increase in number very rapidly, due ordinarily to the favorable warm temperature and the presence of desirable food, i. e., milk sugar, casein, and albumin. Their increase depends primarily upon the temperature. If it is low (50° to 40° F.), a very slow increase occurs; if higher (75° to 100°), a much more rapid increase occurs. This increase or growth results in the breaking up of some of the milk sugar, casein, and albumin, with the formation of by-products as mentioned above. That the quantity and quality of these by-products depends upon the kind of bacteria present and their growth should be constantly kept in mind and all practical efforts made to exclude the bacteria and control their growth.

CLEANLINESS.

The importance of cleanliness can not be overemphasized. In our haste to accomplish a task we often sacrifice our better judgment, only to learn that haste at that stage of the work necessitates a waste in time and labor at a later period. This is particularly true in handling milk and cream that is to be used in the manufacture of butter on farms. The bodies of the cows, the utensils, and the conditions at the barn, the milk room, and storage room should all be clean. These are the primary factors which affect the cleanness of milk and cream.

BODY OF COW.

The body of the cow should be kept clean. There probably is no greater source of contamination to milk than that of dust, hairs, manure, or excreta falling from the body of the cow into the open milk pail during milking. The types of bacteria which are found associated with this filth are capable of producing very objectionable changes in milk and its products. Their activity is greatly increased by the favorable conditions which, we have noted, exist in warm milk. Anything which tends to favor this accumulation of filth on the cow's body should be removed and the cow kept clean, particularly about the flanks and udder. This can be done very efficiently and easily by keeping the long hairs clipped from the flanks and by wiping the udder with a moist cloth or sponge. The clipping of the flanks keeps the hair short and does not favor the accumulation or retention of filth. That which does adhere can be more quickly and easily removed with a currycomb and brush than if the hair were long and had the manure worked into it sufficiently to form a more or less filthy mat. In addition to keeping the cow's body, especially during milking, free from dust and filth the barn should be free from dust and well ventilated. The feeding of hay or any other feed stuff just preceding milking, which will leave the atmosphere of the barn full of dust, should be avoided. Sufficient time should be allowed between the addition of feed to the feed boxes and the time of milking to permit the dust to settle. In many large dairies this is hastened by use of fine spray or mist, which soon clears the atmosphere of dust. It is well to bear constantly in mind that the two main considerations in securing good raw material from which to make butter are: (1) Obtain a good clean milk; (2) keep it free from contamination by undesirable bacteria.

THE UTENSILS.

The utensils should be of such material and construction that they are easily cleaned and kept so. The interior should be smooth, with no cracks or crevices for dirt and milk remnants to find lodgment and be removed only with difficulty. The surface should be heavily tinned and the seams filled with solder. Tinware should be kept bright and perfect. As soon as any rust spots make their appearance an entrance is given into the soft iron for germs and small particles of decaying matter, which are in consequence removed with much more difficulty. The process of cleaning vessels which have contained milk should be:

First. To rinse them thoroughly in lukewarm water.

Second. Wash thoroughly with the aid of some good soap or cleansing powder in water as hot as the hand will bear.

Third. Thoroughly rinse in hot water.

Fourth. Expose to live steam from one to two minutes or to boiling hot water for five minutes in case steam is not available.

Fifth. Exposure, if possible, in bright sunlight from two to three hours.

In this way the tinware can be kept clean and bright and free from bacteria. Having thoroughly cleaned the vessels the prevention of access of dirt to the milk in process of milking is important.

THE BARN.

The barn should be clean, light, and free from objectionable odors. In order to accomplish this remove the manure not only from the cow stall but from the barn. The cow lot should also be kept free from manure to prevent its getting on the body of the cow. The floor of the barn and stall should be capable of good drainage to insure dry floors. In addition to well-drained floors, dry, clean bedding should be kept in the stalls. Such precautions will reduce the work of keeping the body, flanks, and udder of the cows clean and will remove the greatest source of contamination. The hands and clothing of the milkers should be clean and milking done with dry hands. The filthy habit of milking with hands made wet by a stream of milk from the udder only adds to the possibility of filth being added and should never be done.

THE MILK ROOM.

The milk room should receive equal attention, with respect to cleanliness, as the barn. It should be clean, light, well ventilated, and free from objectionable odors. The separator should be cleaned each time it is used and not allowed to stand with milk in it. Flushing the separator with warm water does not remove the slime and milk constituents from the sides of the bowl. This slime is a suitable food for bacteria, and as a result of their rapid growth the contents of the bowl become a starter for the warm, fresh milk of the subsequent milking. The types of bacteria which develop here are largely those found in the manure, filth, etc., which got into the milk at the barn. These are the most undesirable kind and, their number having greatly increased in the bowl, multiply rapidly in the warm, fresh milk. Not only should the separator and its parts be kept clean, but also all equipment with which milk comes in contact.

THE STORAGE ROOM.

The storage room where milk or cream is stored or held until churned should also be clean, dry, and free from bad odors, such as those from decayed or decaying vegetables or fruit, as well as odors emanating from the kitchen when vegetables or meat are being cooked. Any or all of these odors are slowly absorbed by cream or butter and result in objectionable flavors. The damp, musty cellar is a very objectionable storage room, but when light, cool, dry, and sweet-smelling is often very satisfactory. Whitewash, drainage, and ventilation often make an objectionable cellar a desirable storage room.

TEMPERATURES.

The temperature at which milk and cream is held previous to churning has an even more important effect than the initial number of bacteria present. These minute organisms have been found capable of reproducing themselves at the rate of once every half hour if the temperatures are favorable, but if that temperature is unfavorable their growth is checked and their number increases slowly.

MILK.

The temperature at which the milk should be held, however, depends upon the treatment it is to receive in separation. If it is to be separated by use of a centrifugal separator it should have a temperature of 90° to 92° F. and should be separated as soon after milking as possible. The longer it remains at this high temperature the greater will be the bacterial growth. On the other hand, if it is to be separated by use of some form of the gravity system it should be cooled as quickly as possible to a temperature of 50° to 40° F., which will check the growth of bacteria. The most common forms of the gravity system in use are those known as the "shallow pan" and "deep setting." The former consists in allowing the cream to set in pans (2 to 4 inches deep and 8 to 14 inches in diameter) until the butter fat has risen to the top. It can then be removed by use of a cream ladle, spoon, knife, or some other instrument. The latter, or deep-setting method, consists in the use of a tall can, commonly known as the "shotgun" or Cooley can (8 inches in diameter and 18 to 20 inches high), set in cold water. This latter method is more satisfactory than the former, since it cools the milk quicker to a lower temperature and exposes less of its surface to the atmosphere for absorption of flavors.

CREAM.

The temperature of cream that is most desirable depends upon the methods to be followed. If the cream is to be held for several days in order that a sufficient amount can be collected to justify churning the temperature should be low enough to check bacterial action and retain the cream in as sweet condition as possible until the whole lot can be ripened together. The favorable temperature in such case is 50° F., or lower if practicable. If the cream is to be ripened and the best flavors obtained a higher temperature is more favorable for the growth of the bacteria which produce those flavors. Study and investigation of the flavors in milk, cream, and butter have shown that the best flavors are produced by the bacteria which grow at 65° to 70° F. But since this flavor is wanted only at the time cream is churned, it is most satisfactory to hold them in check by low temperatures until about 24 hours before churning time. Then raise the temperature to 65° to 70° and retain for 8 to 12 hours and gradually cool the cream to the desired churning temperature, which varies from 52° to 62° F. This temperature should be maintained from 2 to 4 hours, in order to insure proper firmness or texture in the butter. This insures in most cases a desirable flavor in the cream and butter. With the general purposes in mind it is readily apparent that cleanliness and proper temperatures are two fundamental factors in the manufacture of butter, whether it is made on the farm or in creameries.

METHODS OF CONTROLLING TEMPERATURE OF MILK AND CREAM.

It is impossible to produce a desired temperature and maintain it unless there is some accurate means of ascertaining temperatures. The only reliable method is that of using a thermometer. The accuracy and correctness of the thermometer should be unquestionable, and in order to be certain that it is, it is advisable to have the best. There are several practical methods of controlling the temperatures, but definite directions are hardly possible, inasmuch as the conditions on no two farms are identical.

These methods are:

(1) The use of cold water as a cooling agent. This may be either—
    (*a*) Cold running water from springs or deep wells.
    (*b*) Cold nonrunning water from springs or wells.
    (*c*) Water cooled by the addition of ice.
(2) The use of refrigerators or ice boxes.
(3) The use of clean, dry, cold cellars as storage room.

The following table shows very clearly the relative efficiency of cold water and the atmosphere of a cellar for reducing and maintaining low temperatures:

Method No.[1]	Temperature of cooling medium.	Temperature of cream.	Temperature of cream at later periods.								
			30 min.	1 hour.	2 hours.	3 hours.	4 hours.	5 hours.	6 hours.	7 hours.	8 hours.
	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*
1.......	62	92.5	90.5	89.0	87.0	85.0	82.0	80.5	79.0	78.0	76.5
2.......	52	89.0	86.7	83.0	76.7	73.0	70.0	68.2	67.0	65.7	65.0
3.......	52	86.5	83.8	75.6	65.1	62.5	60.5	59.0	58.0	57.0	56.1
4.......	52	85.5	77.0	68.4	63.5	60.5	58.7	57.5	56.4	55.5	55.0

[1] The methods of treatment were as follows: The can of cream was placed, in No. 1, on cement floor of the cellar; No. 2, in cold nonrunning water; No. 3, in cold running water; No. 4, in cold running water and stirred at intervals of one-half hour.

THE RIPENING OF CREAM.

By the ripening of cream is meant the changes it undergoes from the time of separation until it is added to the churn. Upon these changes depends very largely the quality of butter as regards texture and flavor. The temperature at which cream is held determines the firmness or texture, while the flavor is dependent upon the by-products from the bacterial growth.

The purpose of ripening cream is fundamentally that of giving the butter the desired flavor and aroma, but in addition it increases the ease and efficiency of churning. Cream is ripened in one of two ways:

First, it sours or ripens as a result of the action of bacteria which are normally present in milk and cream; or,

Second, it ripens as a result of action of certain kinds of bacteria which are added in what is termed a " starter."

STARTERS.

A " starter " is simply a quantity of curdled milk which has a clean acid flavor and is capable of producing a similar flavor in the cream or milk to which it is added. These starters may be made from skim milk, buttermilk, whole milk, or cream, and are used for the sake of hastening the production of a uniform desirable flavor in the ripened cream and finished butter.

These starters are of two kinds, viz, " natural " starters and " commercial " or " pure-culture " starters. A natural starter is one made by allowing the bacteria normally found in the milk to sour or curdle it. A commercial or pure-culture starter is one made by adding certain kinds of bacteria to the milk or cream and allowing it to sour or ripen as a result of their action rather than as a result of those normally present. Under natural starters we have: (1) Skim milk, (2) buttermilk, (3) whole milk, and (4) ripened cream. These are lots of milk of the kind which the name suggests that have the desired clean acid flavor and are used to hasten the production of that flavor in the cream which is to be churned. The skim-milk or whole-milk starters are made by taking a small quantity of the milk and allowing it to sour naturally, after which it is added to larger quantities of milk or cream. Buttermilk as a starter is hardly worthy of recommendation. If, however, it has a clean, desirable flavor when added to the cream it may prove beneficial.

In making the commercial or pure-culture starters pasteurized skim milk is used. Pasteurization consists in heating the milk or cream to a temperature of 140° to 145° F. and holding for 20 minutes and then quickly cooling to 60° to 70° F. This heating destroys practically all bacteria present. After milk is pasteurized a small quantity is inoculated with a pure culture of bacteria, which increase rapidly and produce the desired flavor in the starter. These pure cultures are prepared at several commercial bacteriological laboratories and can be obtained by butter makers upon order.

The advantages to be derived from use of starters are: (1) It favors the production of a good uniform flavor and aroma in butter; (2) it hastens ripening; and (3) it enables the butter maker to more readily control the quality of his butter.

The temperatures which favor the growth of bacteria during the ripening of cream are 65° to 70° F. The bacteria which produce the most desirable flavors grow best at or above these temperatures, while those which increase and act at lower temperatures are less desirable. It should be the object of every butter maker to produce a clean acid flavor in the cream and to churn when this flavor has been attained, so that it may be absorbed by the fat and be present in the finished butter.

METHODS OF DETERMINING THE RIPENESS OF CREAM.

In the making of butter it is essential that the ripening of the cream be controlled and that an accurate method of determining the proper degree of ripeness, with respect to flavor and aroma, should be understood and applied by the farm butter maker. There are at present several methods of determining the percentage of acidity in cream. This acidity, however, is only an indicator of the flavor and aroma and must be supplemented by the sense of taste and smell. Cream will become stale and yeasty in flavor without any very great increase in acidity after a certain stage is reached. This seems to be often the case in cream from which dairy butter is made. The most common and probably the most practical method of determining the ripeness of cream is by taste and smell. The flavor should be clean, rich, and free from anything objectionable. If the flavor is once well understood and recognized the butter maker can with some degree of accuracy maintain it, if intelligent efforts are made. Another very common practice is to judge by the appearance of the cream. When thoroughly ripe it thickens slightly and takes on more or less of a glossy appearance. These two methods are common among farm butter makers. Among creameries another method known as the "acid test" is very generally in use. This consists in determining the per cent of acid present in the ripened cream. Experience has shown that cream containing 0.4 to 0.5 per cent of acid has ripened sufficiently to produce the desired flavors and aromas.

This test is made by the use of an alkaline solution and an indicator. It is made in the following way: A definite amount of cream is taken in a glass or cup with white interior. To this cream a few drops of the indicator are added. The alkaline solution is then slowly added to the cream until a permanent slight pink color appears. The indicator, which is colorless in presence of an acid and a deep pink or red in presence of an alkali, serves to show when all acid has been neutralized. The alkaline solution is of a known strength and the cream of known quantity. With these two factors it is possible to quickly calculate the percentage of acid. Apparatus and solutions necessary, along with directions for making the test, can be secured from practically all dairy supply houses.

During the ripening the cream should be stirred thoroughly and frequently. This insures uniformity and prevents the butter fat separating from the milk constituents of the cream. It was mentioned previously that bacteria do not act upon the butter fat, but upon the other constituents. If the butter fat rises to the top of the cream, as it will if not stirred, the flavor and aroma will not be uniformly absorbed. The milk or lighter cream in the lower part of the vat or cream can will sour more quickly, curdle, and probably result in white specks of curd being incorporated in the butter. To prevent this and insure uniform ripening, cream should be stirred. Cream should be run through wire strainers to remove and break up curd particles.

COLORING THE BUTTER.

The uniformity in appearance and attractiveness of butter is greatly increased by the color. The most desired color is that usually found in butter produced in June, when cows are having large amounts of green, succulent feed. Butter makers endeavor to maintain a uniform color throughout the year by the use of "butter coloring." The amount of color varies with the season, but is usually at the rate of from one-half to 1½ ounces of color for each 25 pounds of butter, which is about one-half to 1½ teaspoonfuls for each 3 pounds of butter. This color should be added to the cream just after cream has been put in the churn and before churning has begun.

CHURNING.

Churning is a process of removing butter fat, which exists in minute globules, from milk or cream. This is accomplished by agitating the cream thoroughly, thereby causing the fat globules to come into contact with each other and cohere as a result of concussion. The composition of cream affects the ease of churning. It is composed, as we know, of butter fat and milk serum. The percentage of butter fat affects the proximity to each other of the fat globules which exist in suspension in the serum of milk and cream. Globules are much nearer each other in cream than in milk and nearer each other in 40 per cent cream than in 15 per cent cream. The effect of temperature upon these minute fat globules is to harden or soften them, just as it does lard, tallow, and other fats. A low temperature hardens them; a higher causes them to become soft. The ease or readiness with which they adhere to each other upon coming in contact is dependent upon their softness. If they are too firm they do not adhere readily.

With these few facts in mind, it is well to note the most important factors which influence the process of churning. These factors are:

(1) The per cent of butter fat in cream.
(2) The temperature of the cream.
(3) Fullness of the churn.
(4) Speed of the churn.
(5) Breed of cows.
(6) Individuality of cows.
(7) Time in the period of lactation.
(8) The feed of cows.
(9) Acidity of cream.

A brief discussion of these factors will bring out more clearly the effect of each.

(1) As noted above, the percentage of butter fat determines the proximity of the fat globules to each other and affects the chances of their coming into contact during the churning or agitation of the cream.

(2) The temperature of these fat globules determines their softness and the ease with which they adhere and form the small granules. These unite with others until they become visible in granules as large as wheat and corn kernels.

(3) The fullness of the churn affects the amount of agitation which is possible during the revolution of the churn. If the amount of cream is small it may adhere to the walls of the churn and receive little or no agitation. On the other hand, if the amount is too large the churn will be so full that very little room will be left for the agitation and concussion.

(4) The speed of the churn also affects the amount of agitation the cream receives. If it is revolved too rapidly the centrifugal force is sufficient to cause the cream to remain in one end without causing agitation. If it is revolved too slowly the cream flows from one end of the churn to the other and does not receive agitation or concussion.

(5) The size of fat globules in milk varies according to the breed.

The larger these globules the more quickly and easily they unite. Hence their effect on the time required for churning.

(6) The production of large and small fat globules varies in individual cows. Some produce a larger percentage of large fat globules than others. Hence the churning time is affected by the individuality of the cow.

(7) The stage in the period of lactation is also an influencing factor because of its effect on the size of the fat globules and for other reasons not yet fully understood. In the earlier part of the milking period cows produce milk containing larger fat globules than they do during the latter months.

(8) The effect of feed upon churning is due to its effect upon the composition of the fat globules. It is generally conceded that a green succulent feed, like grass, green corn, ensilage, etc., tends to increase the softness of the fat globules, while a dry feed, such as grain and hay, causes a harder butter fat.

(9) The acidity of cream probably affects the time and completeness or efficiency of churning. The ripened cream will probably churn in less time and more efficiently than sweet cream; hence, if it is necessary to churn quantities of cream which have been collected from day to day, as is almost universally true in farm butter making, they should be mixed together a few hours before churning in order that the acidity will be uniform throughout the whole quantity.

While all these factors affect the time and labor required for churning, the most important ones are the percentage of fat in cream, the temperature of the cream, and the fullness and speed of churn. If these four factors are carefully controlled, little difficulty in churning will be experienced. The cream for churning should contain at least 25 per cent butter fat, should be at such a temperature that it will churn in 25 to 30 minutes, giving a firm, granular butter, and should be sufficient in quantity to fill the barrel churn between one-third and one-half full. The churn should be revolved so as to give the greatest agitation and concussion possible.

THE OBJECT OF CHURNING.

In churning, the butter fat globules should be massed into granules in order that it can be more easily separated from the other milk constituents. The separation of this butter fat with ease and efficiency makes churning one of the most important steps in the production of butter either in creameries or on farms. The degree or amount of churning is dependent upon the size of granules desired. This varies in practice, but if the purpose in having them a definite size is thoroughly understood the efforts at controlling their size can be more intelligently made. The purpose or object in controlling the size of the butter granules during churning is threefold: (1) Removal of buttermilk; (2) more even distribution of salt; and (3) finer grain or texture.

The buttermilk can be most thoroughly removed if butter is in the form of granules varying in size from that of corn kernels to peas. The massing of butter into lumps as large as a walnut or a man's fist results in the incorporation of buttermilk and makes removal by washing very improbable. Again, if butter is in small granules the salt can be more easily distributed and the butter be more uniformly salted. The amount of working necessary is reduced and results in a finer grain and texture. If the butter is in one mass when the salt is added the working necessary to distribute the salt will usually injure the body. The size of the granules can be controlled by stopping the churn frequently after the butter breaks. The churn should be stopped when butter is in granules as large as corn kernels or peas.

WASHING THE BUTTER.

After the churning has been completed the buttermilk should be drawn off through a fine-meshed strainer to prevent loss of small particles of butter. When the buttermilk has been removed the butter should be washed with cold water which is a few degrees colder or warmer than the buttermilk was. This temperature depends upon the butter. If it is too soft use colder water; if too firm use warmer water. The reasons for washing butter are three: (1) To remove the greater part of the buttermilk, and in many cases to improve the flavor; (2) to improve the keeping quality; (3) to " firm " or harden the butter so that it can be more easily handled and neatly packed. The method of washing depends somewhat upon the kind of churn in use, but the primary object is the same, viz, removal of the buttermilk. In a barrel churn, if an amount of water equal to that of the buttermilk is used, 8 to 12 revolutions is generally sufficient to remove the buttermilk. When washing is completed the butter should still be in the granular condition.

SALTING THE BUTTER.

After drawing off the wash water the granular butter should be salted. The amount of salt necessary varies. If the reasons for salting are kept in mind the amount necessary can be readily determined. There are three reasons for salting: (1) Improvement of the flavor; (2) satisfying market demands; (3) serves more or less as a preservative.

There are several methods in use among butter makers for determining the amount of salt to be added to butter. In creameries salt is usually calculated upon the butter-fat basis, i. e., from the weight of cream and percentage of butter fat the pounds of butter fat are calculated, and for each pound of butter fat a definite amount of salt is added. This amount varies from one-half ounce to 1½ ounces per pound, dependent upon demands of the market. In the larger dairies, where from 50 to 500 pounds are made per week, probably the most common method is to weigh the granular butter after washing has been completed, and add a definite amount of salt for each pound of butter. This amount varies in different localities from one-half ounce to 1½ ounces per pound. When this practice is followed the salt should be sifted evenly over the granular butter by use of a fine-meshed sieve. This prevents the addition of lumps of salt, which would be dissolved and distributed with difficulty.

In the small farm dairies, where from 5 to 10 pounds are made per week, it is usually the practice to estimate the weight of butter and guess at the amount of salt necessary. This practice is not to be recommended on account of the great lack of uniformity in salting which results. Either the practice followed in creameries or the larger dairies should be used. Weighing both the butter and salt is probably the more practical.

WORKING THE BUTTER.

After the addition of the salt the butter should be worked. The purposes of working are: (1) To distribute the salt; (2) to produce a compact, firm, close-textured body; (3) to expel moisture and buttermilk.

The amount of working necessary to distribute the salt depends upon the granular condition of the butter and salt. If the butter is in lumps or is very firm more working is required than if butter is in small granules. If the salt is not well pulverized and fine grained it is hard to dissolve and distribute. It dissolves and is distributed more easily in a fairly soft butter than in a very firm, hard butter.

The desired body is also dependent upon the granular condition and firmness of the butter. When the granules are small and very firm working requires more effort. When they are too soft the butter requires less working, but is very likely to be lacking in texture, i. e., without a granular appearance, when the broken surface is examined.

Three points should be observed in determining whether butter is worked sufficiently: (1) It should present a firm, glossy appearance; (2) the texture, especially at later examinations, should resemble the granular structure of broken end of steel rod; (3) there should be no grittiness due to the unevenly distributed or undissolved salt. This can be determined by taking a small piece of butter between the teeth and biting into it repeatedly. Any grittiness will soon be observed.

Insufficient working is generally shown by a mottled appearance in color on the cut surface. This is largely due to an uneven distribution of salt. Overworking is usually shown by a poor grain or texture. This results in a salvy condition and injures the keeping quality. The aim of butter makers should be to produce a high-grade article that is uniform week after week in flavor and composition. This can be done by careful methods in ripening, salting, and working.

PRINTING AND PACKING BUTTER.

The printing and packing of butter is the first and fundamental step in getting it on the market or before the consumer, and should be given careful attention. The greatest lack of uniformity in farm butter is probably that apparent in package or printing. The objects to be attained are: (1) Convenience in handling; (2) attractiveness for the consumer; (3) source of advertising to the producer.

Success in making the butter attractive, convenient to handle, and an advertisement in itself will make profit more probable if care be taken in the production of a good quality of butter. With such attributes butter can usually be profitably marketed.

The packages now in use among farmers are crocks, fiber boxes, parchment papers and cartons, dishes, buckets, pans, etc. The use of some of these packages make attractiveness and convenience impossible. The most desirable and attractive forms of packages are the 3, 5, or 10 pound earthen crocks and the 1 or 2 pound prints wrapped in parchment papers. These wrapped prints are in some cases inclosed in pasteboard cartons or boxes. The name and address of the producer and a brief statement concerning the butter is usually printed upon the paper or carton. This serves as an advertisement and makes a trade-mark possible whereby the public may know what to call for and know whether the butter received is the butter that was asked for. This should lead to an increased demand for that particular product.

MARKETING THE BUTTER.

The original and ultimate object in the production of farm butter, as in any other product, should be production at a profit. This profit, being dependent upon the marketing, should make the efforts toward securing a suitable market greater than is usually the case. The objects to be gained in marketing are: (1) Patrons who appreciate and are willing to pay for a butter superior in quality and appearance; (2) a constant steady market; (3) satisfied customers, which will result in an increased demand.

With these points in mind it is well to state the kinds of market that are available and which are being profitably taken advantage of in different sections of the United States. These are classed as follows: (1) Private customers, e. g., individuals, hotels, and restaurants; (2) selected grocery stores; (3) summer hotels in certain localities; (4) commission houses in nearby cities.

DAIRY EQUIPMENT.

Up to this point little has been said about the kinds of utensils and equipment necessary for manufacture of butter on the farm. The fact that utensils and equipment are not the fundamental factors has led to the delay in their discussion. Excellent butter is in many cases made by the use of the most antiquated and crude equipment. The quality of the butter is dependent upon the intelligent use of rather than the kind of equipment. The convenience and desire to save time and labor should, however, be sufficient to induce butter makers to endeavor to get the most suitable equipment that the market affords. The improvement and time saved due to intelligent use of the most suitable dairy equipment will result in a profit and satisfaction that is not possible with the antiquated equipment of our forefathers.

The dairy equipment should consist of:

Apparatus for determining percentage of fat in milk and cream. (Babcock tester, bottles, milk-record sheets, etc.)
Some means of heating water—a boiler.
Milk pails.
Hand and floor brushes.
Milk strainer.
Cream separator.
Milk cans.
Floating dairy thermometer.
Cream-ripening vat.
Tank for cold water (used in maintaining low temperatures of milk and cream).
Cream stirrer.
Cream strainer.
Barrel churn.
Butter worker.
Butter ladles.
Scales or spring balance.
Butter printer.

Parchment paper or other butter packages.
Butter delivery box.

While all of this equipment is not absolutely necessary, it can be used to advantage. The needs of the individual dairy will determine which can be best omitted. A brief discussion of the construction and purpose of each, accompanied by illustrations, may be serviceable:

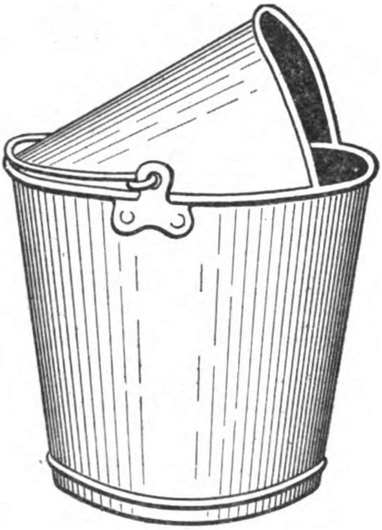

Fig. 1.—Covered milk pail.

Milk pails should be of such construction as to enable them to be easily cleaned and kept bright. This is best accomplished by having the inner surface of the pail smooth and free from seams or crevices which serve as a place for dirt to accumulate and make its removal difficult. The pails should have the seams smoothly soldered and should be heavily tinned to prevent rusting. They should have a narrow or covered top to exclude as much falling dirt as possible. (See fig. 1.)

Brushes should be used in cleaning the pails and other utensils about the dairy. They are much more efficient, convenient, and easily cleaned than dishcloths. The pails should be thoroughly cleaned after each usage by first rinsing with warm water, using a stiff ox-fiber brush and some cleansing powder to remove any particles of dried milk or other substances which would be deleterious to milk that was later drawn into them. After this brushing and cleaning with warm water the pail should be rinsed with boiling or scalding water. The heat imparted in this way will be sufficient to dry the pail and destroy the bacteria which are present, thus leaving the pail clean for subsequent usage. Floors of dairy room should be kept clean. The floor brushes in use are very efficient for this purpose (see fig. 2).

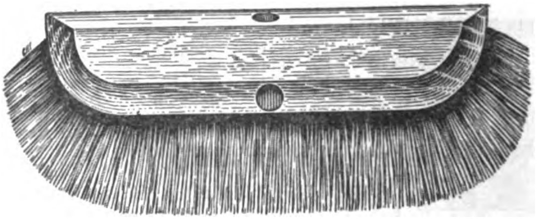

Fig. 2.—Floor brush.

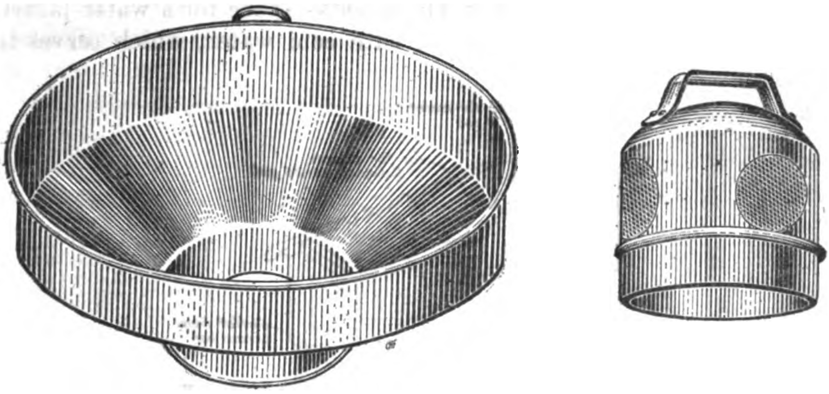

FIG. 3.—Milk strainer, showing center removed.

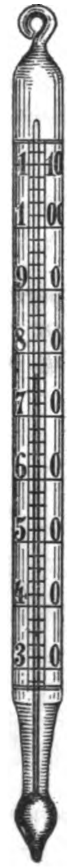

FIG. 4.—Floating dairy thermometer.

The milk strainer should be of the size most suitable for the dairy. The strainer part should be of wire gauze having a small mesh to remove as much of the dirt particles as possible. It should be cleaned in the same manner as the pails and kept sweet by scalding. The body should be smooth and free from seams (see fig. 3).

The cream separator.—The points to be considered in a separator are: (1) Ease of operation, (2) efficiency, (3) durability, (4) capacity, (5) height of feed can from the floor, and (6) ease of cleaning. These requirements are met by most of the standard make of machines.

Milk cans.—The size of cans necessary is dependent upon the quantity of milk to be handled. The cans most frequently used are known as the 3-gallon or "shotgun" can, and the 5 or 8 gallon cans. They should possess the same characteristics so desirable in milk pails, viz, smooth, heavily-tinned interior, to prevent rusting and difficulty in cleaning.

Floating dairy thermometer.– A thermometer should be intelligently used by every butter maker. The control of temperatures is one of the most important parts of dairy work, and can be done more efficiently if definite knowledge is obtainable. The floating dairy thermometer, which is very convenient, makes this knowledge possible. It should be accurate and reliable. Such a thermometer is easily cleaned (see fig. 4).

Cream ripening vat.—The ripening vats used in some of the larger dairies are very convenient and efficient. The vat is surrounded by a wooden box which leaves space for a water-jacket. This jacket or space is kept filled with cold water, which serves to cool and control the temperature of cream during the period in which it is collected and ripened. Cream can be warmed or cooled by filling this compartment with warm or cold water. (Fig. 5.)

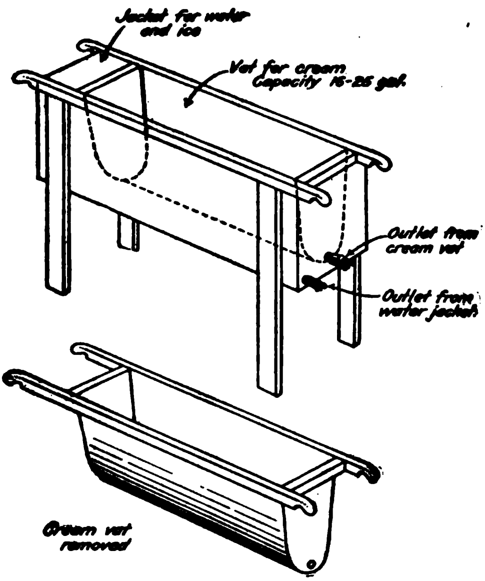

FIG. 5.—Cream ripening vat.

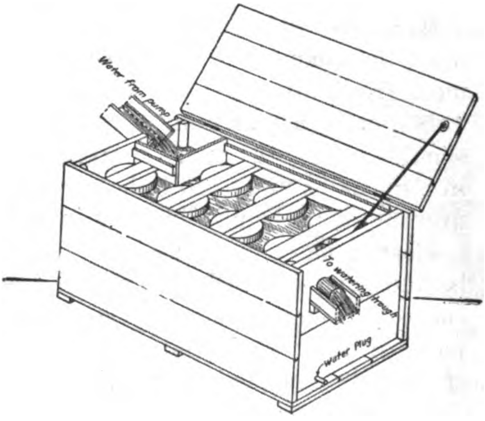

FIG. 6.—Tank for cold water.

A tank for cold water will serve the same purpose and can be used in maintaining low temperatures of milk and cream. Such a tank is very commonly used among farmers, with very good results. The milk or cream in the Cooley or "shotgun" can (8 inches in diameter and 20 inches deep) is set in the tank of cold water (figs. 6 and 7).[1]

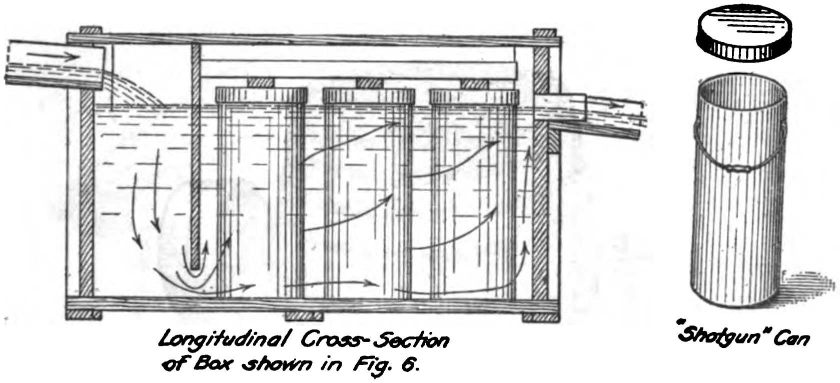

FIG. 7.—Tank for cold water.

The cream stirrer may be of any form. It should be used frequently. The object of stirring cream is to keep the fat and other cream constitutents thoroughly mixed, so that the ripening may be uniform and no large curd particles will form and later appear in the butter as white specks. This thorough mixing will make the absorption of flavors and aromas by the butter fat more uniform. One type of stirrer is shown in figure 8.

A cream strainer should be used when cream is being added to the churn. Straining at this time through a somewhat larger meshed gauze will break up any curd particles which may have been formed and reduce the probability of white specks appearing in the butter (see fig. 9).

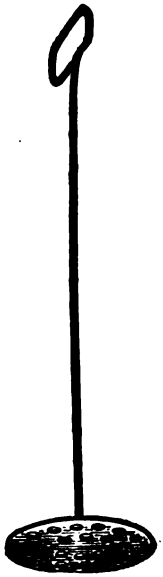

FIG. 8.- Cream stirrer.

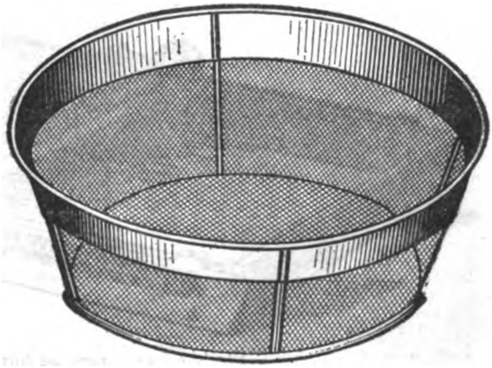

FIG. 9.—Cream strainer.

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[1] Illustration from Bul. 17. Dairy and Cold Storage Commissioner's series. Canada.

A barrel churn is generally recognized as the most convenient and efficient kind in use. The absence of inside fixtures makes the operation and cleaning easy. The churning is due to agitation and concussion, which is not likely to injure or destroy the granular structure so desirable in butter. These churns may be operated either by hand or some mechanical power. The use of a pulley instead of a crank makes it possible to transfer power by means of a belt from other machines, such as gasoline engines, electric motors, treadmills, windmills, etc. The farm separator may also be operated by the same power (see fig. 10).

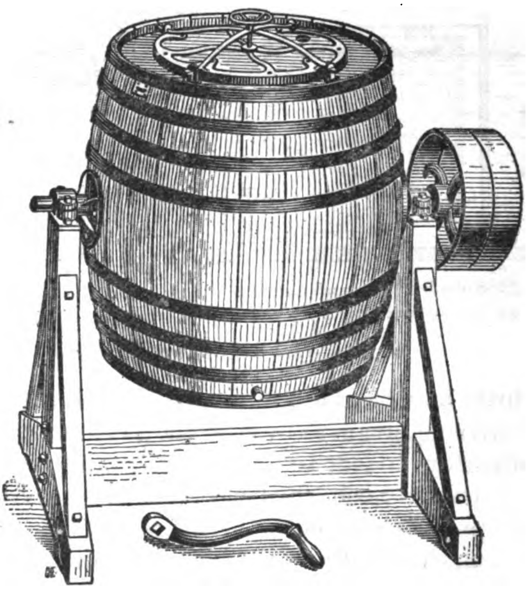

FIG. 10.—Power churn.

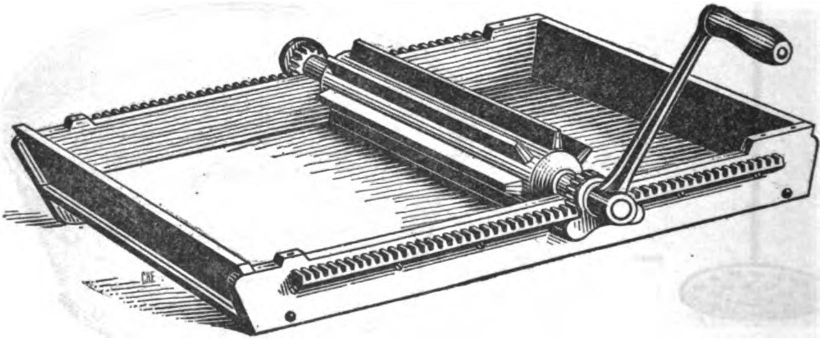

FIG. 11.—One type of butter worker.

The butterworker should be easy to operate, convenient, and efficient. In working, the salt should be distributed and the butter worked into a firm, close-grained mass without injuring the texture. This seems to be most easily accomplished by use of a worker having a corrugated roller which is passed backward and forward over the butter. This distributes and works in the salt without injuring the grain or body. The butter can be more uniformly worked and with greater ease than with some of the other workers (see figs. 11 and 12).

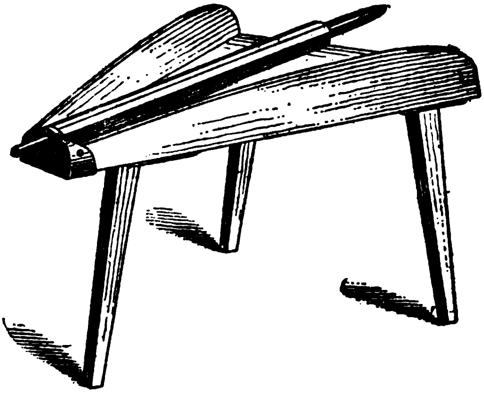

FIG. 12.—Lever butter worker.

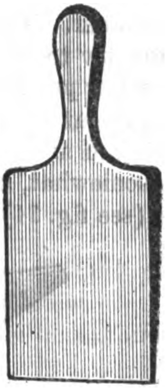

FIG. 13.—Wooden ladle.

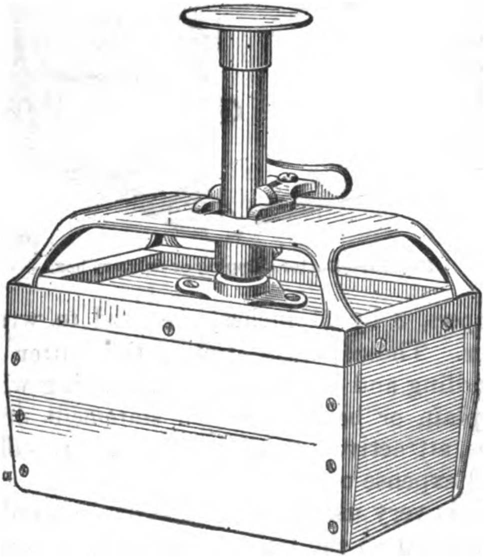

FIG. 14.—One-pound Butter printer.

Butter ladles.—Butter should not be touched or handled with the bare hand. The heat of the hand injures the body of the butter and in addition is very insanitary. The consumers of butter object to eating butter with finger prints upon it. Wooden ladles, as shown in figure 13, are very satisfactory.

Scales for weighing the butter and salt should be used by every butter maker. Their use insures greater uniformity in salting and adds greatly to the satisfaction of knowing what is being done.

The butter printer enables the butter maker to put the butter up in a uniform, neat package from week to week. The most popular, convenient, and attractive form is that of the 1-pound print. The form varies somewhat, but the most commonly used is one 4⅝ by 2½ by 2⅜ inches (see fig. 14).

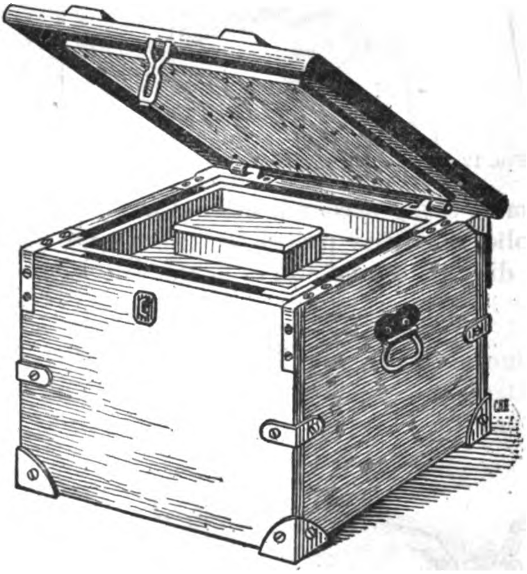

FIG. 15.—Butter shipping or delivery box.

Parchment papers, 8 by 11 inches, are used to wrap these pound prints of butter. These papers protect the butter from dust and dirt during handling and are also used in showing who the maker is. They may be plain or bear a printed statement or advertisement. The convenience, attractiveness, and protection are sufficient to justify the slight added expense of their use.

A delivery box is very useful and necessary in handling butter. It should be constructed so the butter may be kept cool and in a firm condition throughout the time necessary for delivery. This can be done by having a deep rectangular can of crushed ice in the central part of the box. The pound prints can be placed around this and kept from becoming soft and difficult to handle. The use of ice throughout the process of making and marketing butter should be more common (see fig. 15).

CONCLUSIONS.

In conclusion, it may be well to add a few brief instructions:

(1) Keep good cows that will produce from 200 to 300 pounds or more of butter fat annually.

(2) Feed them liberally; follow methods commonly employed among feeders in the cow-testing associations.

(3) Keep the cows comfortable and clean when in the stable. Comfort is conducive to best production.

(4) Skim a rich heavy cream of not less than 25 per cent fat. The fat can be regulated by adjusting the cream screw.

(5) Keep an accurate, reliable thermometer at hand and use it intelligently.

(6) Keep the cream cool. It should be as near 50° F. as possible, if it is desirable to keep it sweet and check bacterial action.

(7) Cream should be ripened before churned; 65° to 70° F. favors the growth of the bacteria which produce desirable flavors in cream. The number of desirable bacteria can be increased by the use of "starters." Cream should not be ripened for too long a period. It soon develops objectionable flavors. Stir the cream frequently during ripening to insure uniformity.. Strain the cream through wire-gauze strainer to break up or remove the curd particles.

(8) Churn at a temperature that will give a firm, flaky granule in the butter. This temperature varies slightly with the season, but ranges from 52° to 62° F. The use of a thermometer and intelligent observation, as result of a few churnings, will enable the butter maker to determine the proper temperature at which to churn. Churn should be stopped when butter granules are large as corn kernels or peas. Time required for churning should be 25 to 30 minutes.

(9) Use clear, pure water for washing the butter. It should not be more than 3° colder or warmer than the buttermilk. Use amount of water equal to that of buttermilk. In barrel churn revolve 12 to 15 times in washing.

(10) Weigh the granular washed butter and salt at the rate of three-fourths ounce to 1 ounce per pound. Be sure the salt is well pulverized and sift it evenly over the granular butter before any of the moisture is worked out.

(11) Work the butter sufficiently to distribute salt without injuring the grain or texture. Determine working by (1) appearance, (2) texture, (3) grittiness.

(12 Put the butter up in clean, neat, attractive packages.

(13) Keep everything in and about the dairy clean and attractive

(14) Make earnest and conscientious efforts to obtain and retain profitable markets.

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Issued July 9, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 542.

CULTURE, FERTILIZATION, AND FROST PROTECTION OF CITRUS GROVES IN THE GULF STATES.

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BY

P. H. ROLFS,

Director of the Agricultural Experiment Station of Florida.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., April 11, 1913.

Sir: Many requests are received at the Department of Agriculture for information on the methods employed in growing oranges and other citrus fruits in Florida and the Gulf States, and it is important that the Department be able to supply the desired information as fully as possible. In order to furnish this information in concise form, Prof. P. H. Rolfs, Director of the Agricultural Experiment Station of Florida, has revised Farmers' Bulletin 238, entitled "Citrus Fruit Growing in the Gulf States," and has divided the material contained in that publication into three parts, of which this paper is the third, as follows: "Sites, Soils, and Varieties for Citrus Groves in the Gulf States"; "Propagation of Citrus Trees in the Gulf States"; "Culture, Fertilization, and Frost Protection of Citrus Groves in the Gulf States." In this form the information will be more available for distribution in the territory directly concerned and will be of more service, it is believed, to prospective growers of citrus fruits and to planters already engaged in this industry. I have the honor to recommend that the paper be published as a Farmers' Bulletin.

Respectfully,

Wm. A. Taylor,
Chief of Bureau.

Hon. D. F. Houston,
Secretary of Agriculture.

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B. P. I.—890.

CULTURE, FERTILIZATION, AND FROST PROTECTION OF CITRUS GROVES IN THE GULF STATES.

INTRODUCTION.

The growing of citrus fruits, an industry which has attained vast proportions in Florida, is receiving much attention in other Gulf States. The purpose of this bulletin is to answer some of the many inquiries constantly received by this Department and to act as a general guide for prospective planters who need definite advice upon questions of citrus-fruit growing. The information is necessarily of a very general character, but the essential factors are presented in a manner which, it is hoped, will enable planters to understand fully the fundamental principles involved.[1]

PREPARATION OF THE LAND.

As a rule, the field chosen to be planted out to an orange grove is land with a native growth upon it. Usually the land is covered with forest trees. Various devices have been used for reducing the amount of labor necessary to get rid of this native growth, but up to the present time no substantial or decided progress has been made in the methods of clearing land. The most of the work is done by main strength and muscular labor. Where the native growth happens to be some form of hard wood, it is the usual practice to remove the trees and stumps. Some advantage is frequently obtained by the use of dynamite or other explosive in loosening the stumps. Where the native growth is pine woods or palm trees, the necessity for removing the stumps is not so great, though in the case of the former the stumps are usually taken out. In cabbage-palmetto hammocks some of the trees are left and used as nurse plants for a few years. The most economical course is to remove all trees, shrubs, and other forms of vegetation from the land and to clear it of all rocks and any other débris that may be found. Then the land may be broken up and put into a first-class state of tilth, which will permit careful staking and planting.

---

[1] For a discussion of other phases of this problem which can not be included here, since to treat them adequately would unduly increase the size of this bulletin, see Farmers' Bulletins 528, Sites, soils, and varieties for citrus groves in the Gulf States; 539, Propagation of citrus trees in the Gulf States; and 172, Scale insects and mites on citrus trees.

SETTING OUT TREES.

Usually the prospective orange grower buys trees from a nursery and sets them out as soon as the field has been cleared, wishing, of course, to get the trees on the land as soon as possible and to hasten the time when he may be selling fruit. Sometimes this is by no means the most profitable procedure. Land especially rich in organic matter and heavily matted with roots from the native growth would be decidedly better for having produced a crop or two of vegetables before the grove is planted. If for any reason it is not desirable to grow vegetables, a crop of weeds grown on it for a year would do much to sweeten the land preparatory to receiving the trees. A crop of cowpeas or velvet beans would be preferable, however.

The number of trees to be set out to the acre depends on the variety selected and the character of the land. Large-growing citrus trees, such as pomelos and the Valencia Late and Hart sweet oranges, should not be set closer than 100 to the acre, and on first-class soil 80 are enough. Smaller growing varieties, such as the mandarin group of oranges and the limes, should not be set closer than 200 trees to the acre. The character of the land will also need to be considered in setting out a grove. In a sandy loam rich in organic matter, especially in southern Florida, trees grow much more vigorously and in consequence should be set farther apart. Forty-nine trees to the acre, i. e., setting them 30 feet apart each way, is about as small a number as one can afford to plant. In the heavy clay soils trees grow less vigorously and may be set nearer together.

TIME AND MANNER OF SETTING OUT TREES.

The time of setting out trees will depend on the location and the conditions. In the West Indies and south Florida trees may be set out at any time of the year when the land is ready and when there is sufficient moisture to favor their growth. In central Florida, the spring (February and March) is preferable. The same is true of north Florida, Louisiana, and Mississippi. In the extreme northern portions of the citrus-growing section it is usually better to wait until the danger of freezing weather is past. This will bring the date up to about the latter part of February. In setting out trees from the nursery, care should be taken to injure the roots as little as possible. Where trees can be taken up with a considerable ball of earth and transplanted in this way, they may be set out without any apparent check in growth. This, however, is not usually practicable.

When the trees are taken up, the roots should be carefully protected by means of wet cloths or moist moss and the trees set in holes already prepared for them. If the ground is not already very moist, the addition of one or two pails of water will usually puddle the roots and cause the trees to grow promptly. At the time of setting out, the tops should be cut back to correspond closely to the condition of the roots. Complete defoliation is also advisable. The favorite size of tree to set out is one that has grown about 4 feet tall in the nursery and has several branches. Such trees are usually about an inch or an inch and a half in diameter at the crown.

CATCH CROPS.

As soon as the field has been set to a grove, cultivation may be begun. The kind and amount of cultivation will be determined by the character of the soil. Light, sandy soil should have shallow but careful cultivation. Heavy clay soils need thorough and deep working. Where there is an abundance of moisture supplied naturally to the soil, other crops may be grown to advantage. Where the soil is inclined to be dry and irrigation has to be practiced, intercropping is of doubtful utility. During the winter, vegetables may be planted and cultivated as in ordinary fields with decided advantage to the orange trees, unless the land is too dry. Leguminous cover crops may be planted as soon as the spring and summer rains begin. When fall droughts occur the cover crops will have to be removed to conserve the moisture of the soil. Cultivation should then be resumed. If the soil is inclined to be sterile the cover crop should be used as a mulch for the trees. If the ground is sufficiently fertile to permit it, the cover crop can be utilized for hay.

PRUNING.

"To prune or not to prune; that is the question." At many of the meetings of the horticultural societies the question of pruning has been vigorously discussed. There are many good reasons for pruning trees; on the other hand, there are reasons why trees should not be pruned. The question, then, must be decided by each individual. One point, however, has been very well settled, and that is that low-headed trees are preferable. Twenty-five or thirty years ago it was a common practice to have citrus trees trimmed high enough to permit a man to drive a cultivator under the branches. The severe cold of several winters has caused this custom to be very largely abandoned. In the southern part of Florida, where there is no danger from frost, it has been found that shading the ground by the limbs has been very beneficial to the grove. Another important advantage in low-headed trees is that the fruit may be gathered much more cheaply than from tall trees.

Nearly all orange growers will agree that the pruning out of dead and worthless branches is of benefit to the tree. The extent to which sound wood is pruned out, however, varies with the notions of the individual grower. Some of the most extensive and best growers in Florida practice no pruning at all. Diseased branches should always be cut out, removed from the orchard at once, and burned. Sprouts that start from below the bud must be removed, and this should be done as soon as possible. Water sprouts arising from the trunks and larger branches should also be removed.

A citrus tree should be kept in a low, compact form, but violent pruning, such as is often practiced in deciduous fruit orchards, is not only unnecessary but often absolutely harmful. Systematic pruning for special purposes is often necessary, but it must be done by a well-directed effort or more harm than good will result.

FERTILIZERS.

Under the general heading of fertilizers may be considered materials which are employed to enrich the soil or cause it to produce a heavier crop. Ordinarily the term "fertilizers" is restricted to such as are considered commercial articles, while the term "manure" is applied to organic offal and refuse accumulating on the farm. In some parts of the United States the term "guano" has been used to designate commercial fertilizers. Cover crops which are grown on the land for the purpose of enriching the soil are frequently called "green manures."

The kind of fertilizer required to produce a heavy crop of oranges varies greatly. In the West Indies, Mexico, Mississippi, Louisiana, and California the general constitution of the soil is so variable that no hard-and-fast rule can be given. In fact, in many cases it is doubtful whether the desired results attend the application of any or all the elements usually needed as plant food. While fertile soils produce trees of vigorous growth which often bear large crops of fruit, the possibilities are necessarily limited to what Nature will do; but in soils where one or more of the elements of plant food are present in insufficient quantity, the modeling of the fruit and the production of excellent qualities are more completely under the control of the skilled horticulturist.

COMMERCIAL FERTILIZERS FOR FLORIDA.

The kind and quantity of fertilizer necessary to produce a maximum crop of fine fruit depend entirely upon the soil in which the tree is growing. Many soils in the citrus regions contain an excess of all the elements necessary for the production of citrus fruits. When fertilizers are applied under such conditions no beneficial effect can be noticed from their use. An orange tree planted in soil that contains large quantities of the necessary elements usually produces large fruit, but often of an indifferent character. Soils that are deficient in nitrogen, potash, and phosphoric acid can usually have these supplied from such sources and in such quantity as will produce fruit of the desired texture and consistency. It therefore happens that the finest and most delicious fruit is grown on rather sterile soil.

The entire piny woods of Florida may be said to be deficient in each of the three important elements of plant food—nitrogen, potash, and phosphoric acid. Soils are also found in which there is a deficiency of lime, so that frequently an addition of this element will prove of value. The hammock soils are usually sufficiently fertile to produce at least one crop, or even a few crops of fruit, without the addition of fertilizer. These, however, in time become depleted, and the elements of plant food then need to be supplied by substances from a commercial source.

In growing citrus fruits on soils that are deficient in all of the three important elements of plant food, a fertilizer of the following composition is desirable:

	Per cent.
Ammonia	4
Potash	10
Phosphoric acid (available)	6

For growing nursery stock or for trees not of a bearing age the amount of potash in the formula may be reduced to 6 per cent, leaving the two other ingredients in about the above proportions.

The quantity of this fertilizer to be applied per acre will depend upon various conditions. About 15 or 20 pounds per year may be applied to each tree capable of producing 10 boxes of fruit, the quantity being decreased or increased from year to year, as results indicate. Calculating this on the basis of 100 trees per acre, 1,500 pounds per acre per year would be used for young bearing trees. Double this amount is very frequently applied, and sometimes three times as much is used.

The following table gives approximately the amount of material needed per acre for bearing trees to supply a quantity of fertilizer equal in fertilizing constituents to 1,500 pounds of the foregoing formula:

		Pounds.
(1)	Sulphate of ammonia	250
(2)	Sulphate of potash, high grade	300
	Or sulphate of potash magnesia (low-grade sulphate of potash)	550
(3)	Dissolved boneblack	550
	Or acid phosphate, 14 per cent available phosphoric acid	850

In the case of nursery stock and growing trees, 2 per cent of the ammonia may be derived from an organic source. This would require approximately the following ingredients:

		Pounds.
(1)	Sulphate of ammonia	125
(2)	Dried blood	100
(3)	Sulphate of potash, high grade	200
	Or sulphate of potash magnesia (low-grade sulphate of potash	350
(4)	Dissolved boneblack	550
	Or acid phosphate, 14 per cent available phosphoric acid	850

If there is any tendency toward die-back the dried blood should be omitted and the amount of sulphate of ammonia increased to 250 pounds. If a quick-acting fertilizer is wanted, nitrate of soda (100 pounds) may be employed in place of dried blood.

Citrus-fruit growers wishing to compound their own fertilizers should give due regard to the substances from which the different qualities are derived.

Organic ammonia, as found in cottonseed meal, dried blood, guano, and the various stable manures, is likely to produce a soft, rapid growth, and in certain sections, especially in Florida, its continued use is almost certain to produce die-back.

Nitrate of soda is soon taken up by the trees, but is easily washed out of the soil. Where it is used as the only source of nitrogen it has to be repeated from four to eight times each year, varying with the amount of rainfall and the character of soil.

Sulphate of ammonia is much slower in becoming available to the trees and seems to be retained in the soil much more tenaciously than nitrate of soda, so that it need not be applied oftener than two to four times a year.

In the use of potash there is very little choice between the low-grade sulphate, which is also called the double salts of potash and magnesia, and the high-grade sulphate of potash.

In selecting phosphates, preference is given to dissolved bone or dissolved boneblack over dissolved rock phosphate, although some experienced orange growers consider the phosphoric acid derived from dissolved rock as good as that obtained from dissolved bone. Thomas slag may be employed to good advantage, especially on soils giving an acid reaction.

The ammonia is washed out of the soil in great quantities by frequent and heavy rains. Potash is washed out to a less degree and phosphoric acid only to a slight extent, while lime, or calcium, is lost in large quantities. The quantity of these elements lost will vary according to the nature of the soil and the amount of heavy rainfall occurring. The ideal way of fertilizing would be to make an application of phosphoric acid in the spring before the rainy season has begun; to make two applications of potash—one in the early spring at the time of applying the phosphate and another in the fall after the rainy season has passed; and to make four or more applications of ammonia—one with each application of the potash and two or more at equal intervals between, except during the dormant winter season.

The following example will serve to illustrate the point: Let us suppose that a grove needs 1,500 pounds of fertilizer per acre per year of the normal formula, that is, 4 per cent ammonia, 10 per cent potash, and 6 per cent phosphoric acid. In the spring, therefore, before the rainy season has begun, we would apply the entire allowance of phosphoric acid, or 850 pounds of 14 per cent acid phosphate; one-half the potash, or 150 pounds of high-grade sulphate of potash; and one-fourth the ammonia, or 62½ pounds of high-grade sulphate of ammonia. These ingredients may be mixed and applied in the usual way. Care must be exercised, however, since such a mixture is a very concentrated fertilizer, and if applied in a narrow zone around the tree injury may result when the weather conditions make possible the too rapid assimilation of the chemicals or when the nature of the soil itself is such that the fertilizer is taken up too quickly.

For the fall application, 150 pounds of high-grade sulphate of potash should be mixed with 62½ pounds of high-grade sulphate of ammonia. The remaining 125 pounds of sulphate of ammonia should be evenly divided and applied as the conditions indicate. In this way the amount of plant food that is contained in 1,500 pounds of fertilizer of standard formula would be applied during the year.

The proper regulation of the amount of ammonia to be applied is the greatest difficulty in preparing a complete fertilizer formula. The presence of this element in too large or too small quantities in the soil or in the fertilizer appears to give more trouble than any other ingredient. Groves are very frequently injured by large applications of ammonia. A very common practice is to make only two applications a year of a complete fertilizer—one during the spring and one during the fall. Other growers make three applications—one during the early spring, one later in the spring, and another during the fall.

STABLE MANURE OF DOUBTFUL UTILITY.[1]

The benefits of stable or barn manure, which is largely used by many growers, are also very doubtful. The fruits produced by nitrogen from this source are usually large, coarse, thick-skinned, and of inferior flavor. If barn manure is used, however, each tree should receive only a small quantity, and where it is the main element of fertilization liberal dressings of potash should occasionally be applied to counterbalance the nitrogenous fertilizer.

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[1] See Yearbook, U. S. Department of Agriculture, for 1894, pp. 195 and 196.

INJURIOUS ACTION OF MUCK.[1]

Some growers claim that since muck is largely decaying vegetable matter it should be applied to the grove in large quantities, either raw or composted with sulphate of potash, etc. While this has occasionally given excellent results, its extensive use has often done serious injury. In order to obtain a smooth, thin-skinned, juicy fruit with few or no seeds, we must vary the fertilization which the plant receives in its wild state. The tendency of all organic manures rich in nitrogen is to stimulate large, sickly growth. Groves which have had liberal dressings of muck are frequently much diseased; their crops are light, the oranges coarse, thick-skinned, and sour, the fruit drops prematurely, and the trees are often affected with die-back. What has been said of muck applies to a greater or less extent to the various forms of organic nitrogen used.

What has been said about the effect of muck and barn manure on the quality of the fruit applies equally to the effects produced by cottonseed meal, blood and bone, tankage, etc. In general, organic fertilizers do not stimulate fruiting to the same extent as the mineral fertilizers.

PROTECTION AGAINST COLD.

The disastrous freezes of 1894, 1895, and 1899 in Florida and those of 1912 and 1913 in California have caused the orange grower to cast about for some means of protection against a sudden cold wave. Two general methods have been practiced: The first is that of warming the air without providing shelter and the second is that of providing a shed or shelter for the trees.

The methods of raising the temperature by means of fires, as described in the following paragraphs, can not be relied on if the cold weather is accompanied by high winds or rainfall. In a portion of Florida during the heavy freeze of 1899 not only a heavy rainfall but heavy winds accompanied the cold. All attempts at building fires were useless, and even if they could have been built the wind would soon have carried the warm air out of the groves.

When a very moderate breeze is blowing and the temperature falls only 4 or 5 degrees below the danger point, fires should be increased on the windward side, perhaps doubled, at the expense of those in the interior, but fires should not be extinguished in the interior of the grove, merely reduced.

PROTECTION BY HEAT.

The burning of different kinds of fuel in an orchard for the purpose of raising the temperature has been employed a great many times. The success attending the work varies under different circumstances and with different conditions. When the drop in temperature is accompanied by a heavy windstorm and rain or sleet, it is almost impossible to accomplish anything in the way of orchard heating. Fortunately, freezing weather in the citrus regions is usually accompanied by a rather still atmosphere and freedom from rain or snow.

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[1] See Yearbook, U. S. Department of Agriculture, for 1894, pp. 195 and 196.

A great many kinds of fuel have been employed for orchard heating. Wood was probably the first, and it is still employed to some extent. Coal, coke, and fuel oil have all been used to a greater or less extent. Each of these fuels may have special advantages over others in some particular place. In general, it may be said that the fuel-oil method has given satisfaction more frequently than all the others combined. To discuss all of the methods fully is quite beyond the purpose of this bulletin.

FUEL OILS.

This term includes a variety of materials known under many different trade names. In general, they are the heavy residue left after the lighter oils contained in the petroleum have been removed. A fuel oil known as crude oil is said to contain a large quantity of asphaltum, which becomes quite troublesome. The asphaltum remains as a residue in the bottom of the heaters and interferes with the heating when the fuel burns low.

HEATERS.

The varieties and styles of heaters offered by the trade are nearly as numerous as the varieties of fuels. Usually the more complicated in construction the heater is, the less efficient it becomes in its practical work in the orchard. Even a 10-pound lard pail, holding more than a gallon of fuel oil, compares very favorably in efficiency with the patented heaters, in some cases even proving superior to them. The lard-pail type of heater, made from heavy sheet metal and holding about 5 quarts of oil, can usually be purchased from heater manufacturers at 10 or 12 cents apiece when ordered in carload lots. In this type of heater the quantity of fuel used and the heat given off decrease gradually as the supply in the heater is consumed.

The lard-pail type of heater holding a gallon of fuel oil will burn for 3½ to 4 hours, varying with the kind of fuel oil used and weather conditions, giving off about one-half as much heat toward the close as at the beginning of the charge. When a soot arrester is used, the quantity of fuel consumed in an hour is much reduced, but at the same time a correspondingly smaller amount of heat is given off. There are a number of heaters that hold a much larger quantity of fuel oil. Most of these are so constructed, either by means of a soot arrester or otherwise, that the quantity of oil burned can be regulated. Ordinarily these are to be preferred to the smaller type, since when freezing weather occurs it is usually of more than four hours' duration. The minimum temperature is very likely to occur about sunrise. Refilling in the dark is difficult and wasteful.

The type of heater with a sliding top to regulate the area of the burning surface has worked quite satisfactorily. Roughly speaking, 44 square inches of free burning surface will consume a gallon of fuel oil in four hours. It has been pretty clearly demonstrated by experiment that it will require the same quantity of oil to raise the temperature 5 degrees in an orchard, whether few or many heaters are used. When many heaters are used the temperature in the orchard can be maintained much more evenly. The number of burners needed per acre to raise the temperature 5 degrees will vary greatly, according to the favorable or unfavorable climatic conditions and the condition of the grove. A small grove of large trees closely planted and surrounded by a dense hammock will pass unharmed through a freeze of 25° F., while considerable damage would be done in a grove not so protected. Likewise, the number of heaters required in the former grove would be fewer than in an open grove where the trees are small and only a few to the acre.

From 50 to 100 heaters and from 100 to 200 gallons of fuel oil per acre for each night when heating is necessary is a reasonably safe estimate in a grove 7 to 10 years old. This number of heaters and quantity of fuel oil will probably keep the temperature 5 degrees above the surrounding atmosphere if the wind is not blowing more than 4 or 5 miles an hour. Ordinarily the heaters are distributed evenly throughout the grove, placing one in every center between four trees. This requires about as many heaters as there are trees in the grove, and is a poor rule to follow absolutely, since a grove of small trees planted far apart will not hold the heat as well as a grove of large trees planted closely. Every grove owner will have abundant latitude to use his own judgment as to the effect of the exposure of his grove and the other elements that enter into the question of orchard heating.

Every grove supplied with heaters should have in it a thermometer that will sound an alarm when the temperature approaches the danger point. Such an instrument can be obtained for from $7 to $20 from instrument manufacturers and dealers. The thermometer should be placed in that part of the grove in which the danger from frost is greatest, and the wires should run to the house or central office.

The danger point will vary with conditions. At blooming time the danger point is highest and injury may then occur whether the temperature goes down to 32° F. or not. Mature fruit is almost certain to remain unharmed unless the minimum temperature falls below 28° F. Trees in a fully dormant condition will remain unharmed at 24° F., but when full dormancy has passed the trees become increasingly sensitive to cold. When in full growth, frost, no matter at what temperature it occurs, will destroy the tender tissues.

Every grove owner should be in direct telephone communication with the United States Weather Bureau, in order to receive warnings of probable frosts and freezes. All the important fruit-growing sections receive this information regularly over long-distance telephones.

STORAGE TANKS.

The fuel oil should be stored in a tank located preferably in the grove. Where possible, it should be so placed as to allow the oil to be siphoned directly into it from the car tank, and then from it into the wagon tank. The storage tank should always be so located as to enable one to run the fuel oil into the wagon tank by gravity. Pumps work satisfactorily in warm weather, but are apt to be troublesome during a cold spell. They also require extra labor, which could be more advantageously employed in the grove. A break in a pump will cause delay and may make the fuel inaccessible, thus rendering the whole plant ineffective.

Fuel oil may be stored in a variety of receptacles, the least desirable of which are barrels. Concrete tanks or cisterns with tops, such as are constructed for holding water, will be found useful. The inner surface should be finished with cement plaster and finally given two or three coats of asphaltum paint. Steel water tanks are in common use. Wooden tanks similar to water tanks, made of upright 2-inch planks, are commonly used and seem to be thoroughly practicable. Some grove owners have tanks such as are used on tank cars for hauling fuel oil, but these would seem to be unnecessarily expensive.

COST OF HEATING.

The estimated cost of preparing to heat a 10-acre grove will vary within certain limits. No two groves would be located exactly alike as to the cost of heating. The distance from the railroad, number of times to be fired, and variation in price of labor all come in as variables.

The following table gives an approximate cost for a 10-acre grove:

500 to 1,000 heaters, at 40 cents	$200	to	$400
One steel wagon tank	25	to	30
Torches and gasoline can for lighting	10	to	12
Thermometers and installing	12	to	25
3,000 to 6,000 gallons of fuel oil	90	to	180
Storage tank for fuel oil	100	to	300
Total	437	to	947

After the equipment has been installed the expense is comparatively light and includes mainly the annual depreciation, care of outfit, fuel oil burned, transfer to storage tank, and labor. The last item will vary from year to year. When no firing is needed this item will be comparatively light. At firing time it will require two or three additional men to take care of 10 acres. An allowance of $6 to $10 for each night fired should be ample, including the cost of distributing the fuel oil for the next charge. In extensive groves and where large-size heaters are used, one man to 10 acres will be sufficient to take care of the fires, but additional labor will be needed to replenish the fuel.

WOOD FIRES.

In a wooded country the form of protection against cold afforded by fires is cheap and at the same time very effective when a still cold occurs. The wood is piled in the centers of the squares, varying in quantity from three or four to a half-dozen or a dozen sticks of cord wood. When a freeze is predicted, the watchers notice the thermometer and by the time the cold approaches within 2 or 3 degrees of the danger point, which is 28° F. for fruit and 24° F. for foliage, fires are started in alternate squares. These will usually heat the grove some 4 or 5 degrees. If the cold continues to increase, all the piles of wood are started. It is of course necessary to have on hand a reserve stock of fuel in such an emergency. Shortly after the sun rises the next morning the temperature will usually have risen again, so there will no longer be any danger to the fruit or trees. If there is no favorable change in the weather, the cold on the second night is quite likely to be more severe than on the first. Firing then must be begun much earlier, and consequently a greater quantity of wood will be needed.

Owing to the large amount of labor involved and the difficulty of securing efficient help, this form of orchard heating has been largely abandoned.

PROTECTION BY IRRIGATION.

In the citrus-growing sections the water that is freshly pumped from the soil is quite warm, ranging from 50° to 74° F. When this water is carried through a grove in irrigating ditches it gives off a considerable amount of heat and has been used effectively in some instances where the temperature has fallen but slightly below the danger point.

Arrangements have also been made to throw this water into the air from spray nozzles. This is somewhat more effective than when the same quantity of water is carried through irrigating ditches, but can not be relied upon as being sufficient during extremely cold spells. During one cold wave the orchard of Mr. Theodore Mead, at Oviedo, Fla., was protected in this way. During one night the temperature fell considerably below the freezing point. The next morning the trees were so heavily coated with ice that some of the branches broke. The following summer the trees bore a crop of fruit.

The waters from artesian wells have also been used for the purpose of warming citrus groves, this water being quite warm, running into the sixties usually and as high as 74° F. in some wells. While this use of water does some good and protects that portion of the grove in the immediate vicinity of the large flow, the amount of heat given off is small and the volume of water supplied is not considered large enough to protect the grove during severe freezes.

PROTECTION BY SHEDS.

The most successful method of protecting citrus trees from extremely cold weather is that of building a shed over the grove. At first thought this would seem to be entirely too expensive and not at all feasible, but the sheds have now been used long enough to demonstrate fully that they are not only possible but practicable. There are several modifications of the shed.

This method was successfully employed immediately after the great freezes and was profitable while Florida oranges brought a high price. Orange sheds now occur to a limited extent and only in regions where great damage from cold formerly occurred. These sheds are simple structures, having a flat roof or cover held up by posts. The posts are properly braced and hold the cover from 12 to 16 feet above the ground. Some of the movable tops are made solid, while those with stationary tops are made of slats or laths so placed as to give either a half or third shade.

TOP-WORKING.

It sometimes happens that a grove is planted out to a variety that does not prove prolific, or one that may be unprofitable to market. In such a case it becomes necessary to abandon the grove or to top-work the trees. With the trees in a healthy and vigorous condition most or all of the top should be removed, only two or three vigorous limbs being left. Buds of the desired variety may be inserted into the remaining limbs. This cutting away of most of the top causes a heavy flow of sap into the smaller limbs which remain. In such cases the buds will "take" where they would fail if the top of the tree had not been vigorously cut back.

Another way of top-working is to cut away nearly all of the top and then wait for sprouts to start. After the sprouts have reached a size of about half an inch in diameter they may be budded, and the bud will take readily. When trees have been cut back severely, the bodies and the larger limbs should receive a heavy coat of whitewash to protect them against sun scalding.

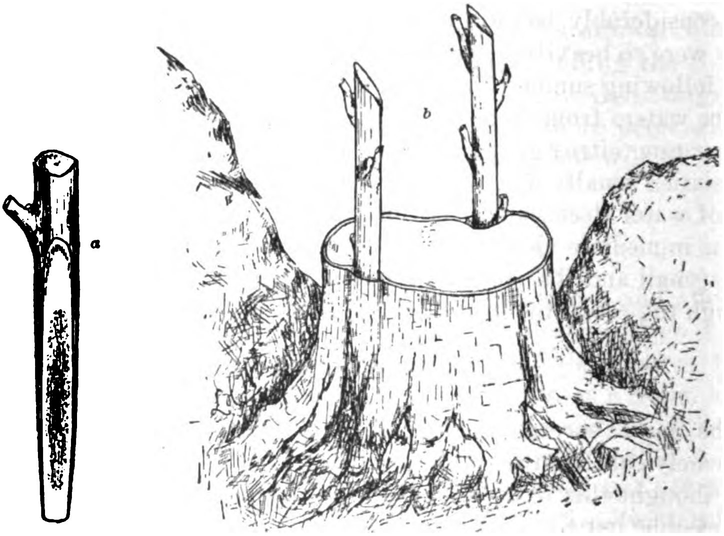

FIG. 1.—Crown-grafting an old orange stock: *a*, Base of scion, showing slanting cut; *b*, method of inserting scion. (From Yearbook, U. S. Department of Agriculture, for 1895.)

Before top-working, the orchardist should be well acquainted with his grove and soil. In a very large portion of Florida severe top-pruning results in die-back unless proper fertilization and soil treatment accompany the work.

In California and Louisiana it appears to be safe to remove the entire top and to work buds into the large limbs. For top-working, the shield bud and sprig graft may be used to best advantage.

CROWN-WORKING.

At times it becomes desirable not to permit the body of the tree to remain. In such cases it may be cut off at the ground line. Some citrus trees, especially limes, resent treatment of this kind and fail to grow after the top has been entirely cut off. The ordinary citrus stock, however, is almost certain to sprout again if treated in this way. Large areas, 20 to 40 acres in extent, were sprouted in this way after the great freezes of 1894 and 1895 in Florida without the loss of a single healthy stump.

Trees that have been cut back in this way may be crown-worked or crown-grafted, as illustrated in figure 1, the sprig being inserted in the portion of the crown that will take it most easily. By slipping the scion into the portion of the crown where the bark may be raised without breaking, the work may be done without the use of wax or other binding material. After the scion has been inserted, moist earth should be raked over the crown and around the scion, covering them until they have "taken," and then exposing the tips. Where this work is done by experienced hands, only a very small percentage of the crowns fail in taking one or more sprigs. Those that fail to take may be worked again or left to produce sprouts and then budded into these sprouts. By using three or four such scions in a crown 4 or more inches in diameter and doing the work during February or the early part of March the percentage of loss sustained will not be very great.

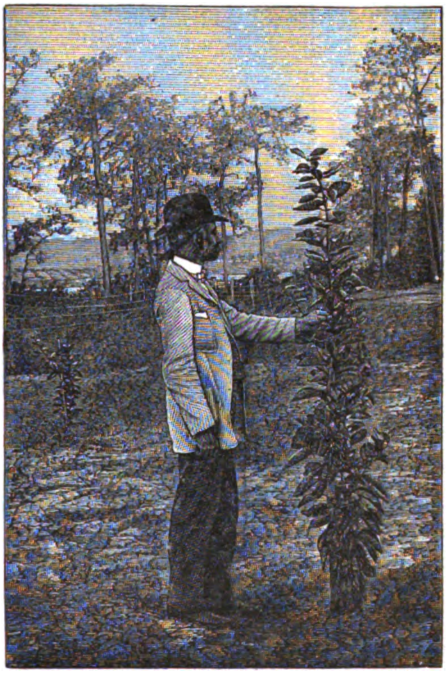
FIG. 2.—Ruby orange bud, inserted May 21, on a sprout from an old sweet-orange trunk, as it appeared on October 25. (From Yearbook, U. S. Department of Agriculture, for 1895.)

Another method of renewing such an orchard is to wait until the sprouts have started from the crown or the main roots. After these sprouts have reached a size of half an inch or so in diameter, buds are inserted as low down as practicable. In doing this, however, a considerable loss of time will be sustained in waiting, first, for the sprouts to start and then, again, in cutting them back to make the buds sprout. The loss of time is strikingly illustrated by the two accompanying figures made from photographs (figs. 2 and 3). This method of budding sprouts, although it results in some loss of time, is nevertheless very commonly used by growers because of its convenience.

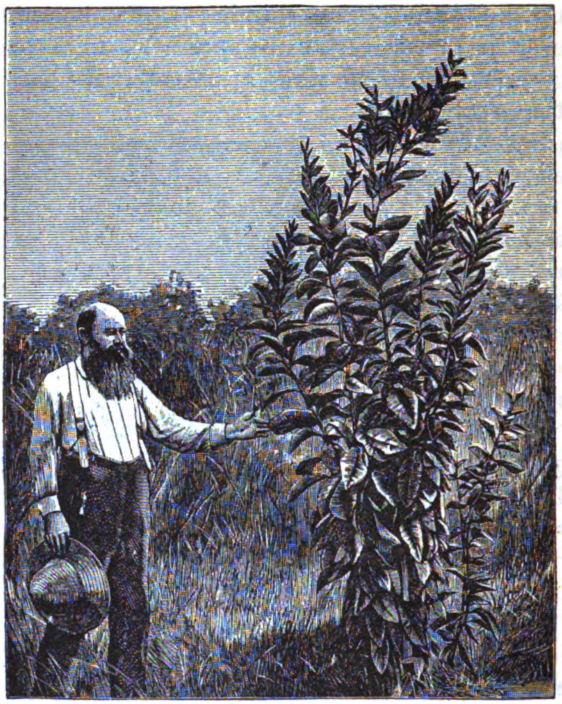

FIG. 3.—Ruby orange crown graft, inserted March 1, as it appeared on October 23.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 543.

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COMMON WHITE GRUBS.

BY

JOHN J. DAVIS,
Scientific Assistant, Bureau of Entomology.

WASHINGTON:
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1913.

LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Entomology,
Washington, D. C., April 19, 1913.

Sir: I have the honor to transmit for publication as a Farmers' Bulletin a brief account of the common white grubs.

A thorough study of the white-grub problem throughout the United States has recently been undertaken by the Bureau of Entomology, cooperating with the office of State entomologist of Illinois, and with the further aid of the Indiana Agricultural Experiment Station and Purdue University. As this investigation has only fairly begun, the present publication is in no sense a report, but is merely intended to give a brief summary of the life history and habits of these insects, as now understood, together with the best known means of controlling them. The bulletin has been prepared with special reference to the destructive outbreak of 1912 and the seemingly strong probabilities of a similar infestation in 1915.

This subject is of the greatest importance to farmers, whose cooperation is much needed in carrying out the work and securing practical results therefrom.

Respectfully, L. O. Howard,
Entomologist and Chief of Bureau.

Hon. D. F. Houston,
Secretary of Agriculture.

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COMMON WHITE GRUBS.[1]

The common white grubs (fig. 1), or grubworms, as they are often called, have for years been recognized as among the most serious pests to farm crops, notably corn and timothy, while strawberries, potatoes, and nursery plantings, particularly of conifers, have all been frequently and seriously affected.

These pests have never been given extended economic study, except by Dr. S. A. Forbes,[2] State entomologist of Illinois, to whom we are indebted for nearly all of our practical knowledge of the parent May beetles (fig. 2) and their progeny, the white grubs.

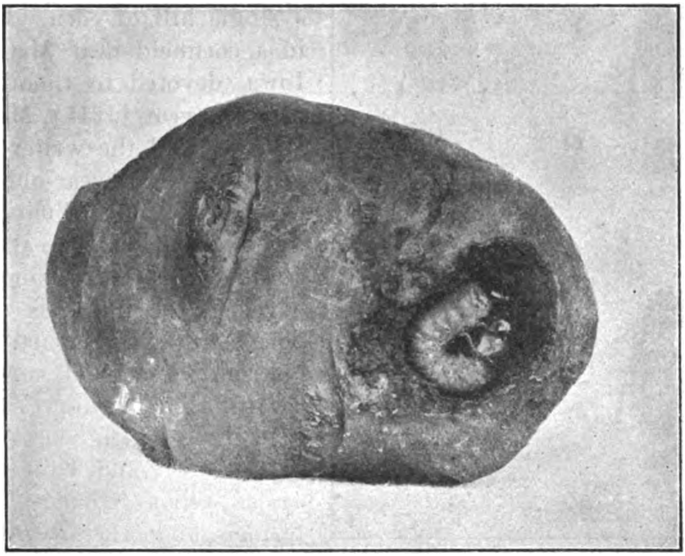

FIG. 1.—White grub working in a potato tuber, Tabor, S. Dak., 1912. (Original.)

THE OUTBREAK OF 1912.

Probably the most serious outbreak of white grubs in the history of American agriculture occurred in 1912, following an abundance of beetles in 1911. Injury was reported from almost every section of the country north of the Ohio River and westward to South Dakota. (See fig. 3.) In the West the center of abundance was in southwestern Wisconsin, while in the East it seemed to be in northeastern Pennsylvania and southeastern New York.

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[1] *Lachnosterna* spp.

[2] Insect Life, vol. 3, no. 5, pp. 239–245, 1891; 18th Rept. State Ent. Ill., pp. 109–144, 1894; Ill. Agr. Exp. Sta., Bul. 116, 1907.

Infestation occurred, however, as far west as Tabor, S. Dak., and though no serious general injury was found west of eastern Iowa there were scattered occurrences in western Iowa and southern Minnesota. Throughout the southern third of Wisconsin and in northern Illinois the grubs were abundant, especially in the western portions of those sections. Many infestations were also reported from southern Michigan and scattered ones from northern Indiana and eastward through Ohio. These infestations again became general in northeastern Pennsylvania, southeastern New York, in Connecticut, and in parts of New Jersey.

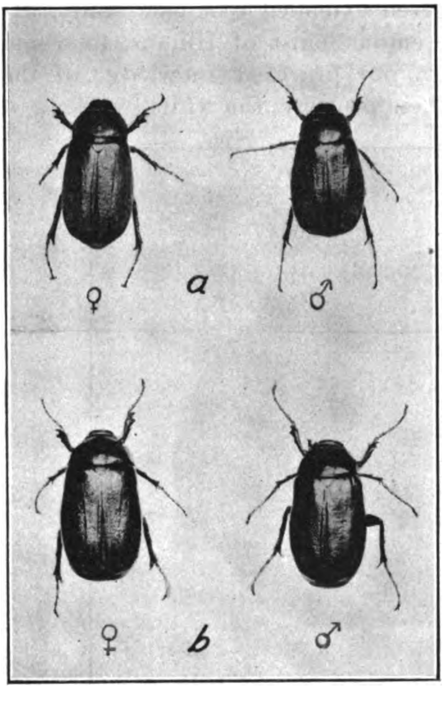

FIG. 2.—Typical examples of May beetles: *a*, *Lachnosterna crenulata*; *b*, *Lachnosterna fusca*. Natural size. (Original.)

In the worst infested districts it was not at all unusual to find from 40 to 60 grubs in a single hill of corn. Indeed, in a cornfield near McGregor, Iowa, devoted to timothy the previous year (1911), Mr. R. L. Webster and the writer found seventy-seven 2-year-old grubs in an area 2½ feet square and 5 inches deep. This really represented less than a single hill of corn, for the hills in this field were 3½ feet apart.

From a personal survey of the infested territory made in 1912 in Iowa (fig. 4), Wisconsin (fig. 5), and Illinois (fig. 6), as well as from reports of farmers and others, we have a very conservative estimate of the damage to corn, timothy, and potatoes in these States, aggregating not less than $7,000,000. The damage to the same crops in the other infested areas can not be figured at less than $5,000,000, which brings the total loss in 1912, exclusive of strawberries, nursery stock, lawns, and miscellaneous crops, to not less than $12,000,000.

POSSIBILITY OF AN OUTBREAK IN 1915.

Available records show that May beetles were unusually abundant in 1908, the grubs causing considerable damage in Wisconsin, Illinois, and other localities in 1909 and again in 1912. The damage, however, was more pronounced in these localities in 1912. As previously noted, the beetles were very abundant in the spring of 1911, thus giving rather conclusive evidence that the life cycle of the more abun-

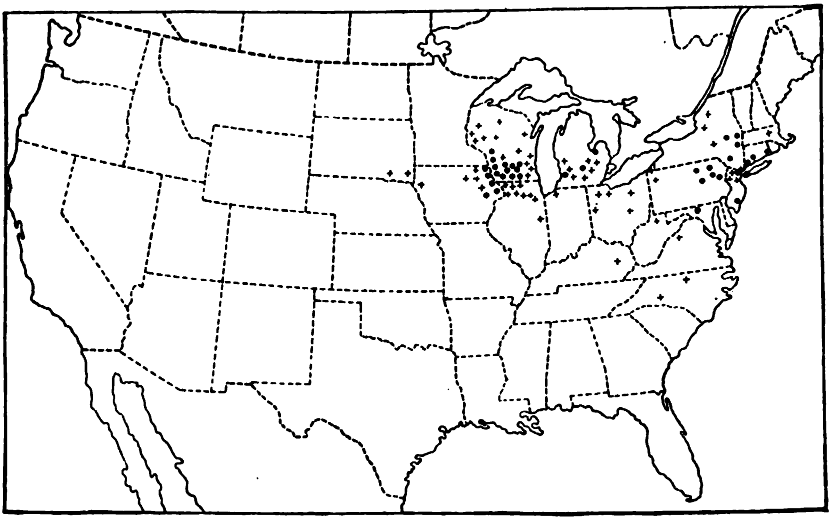

FIG. 3.—Map showing the invasion of white grubs in 1912. (Original.)

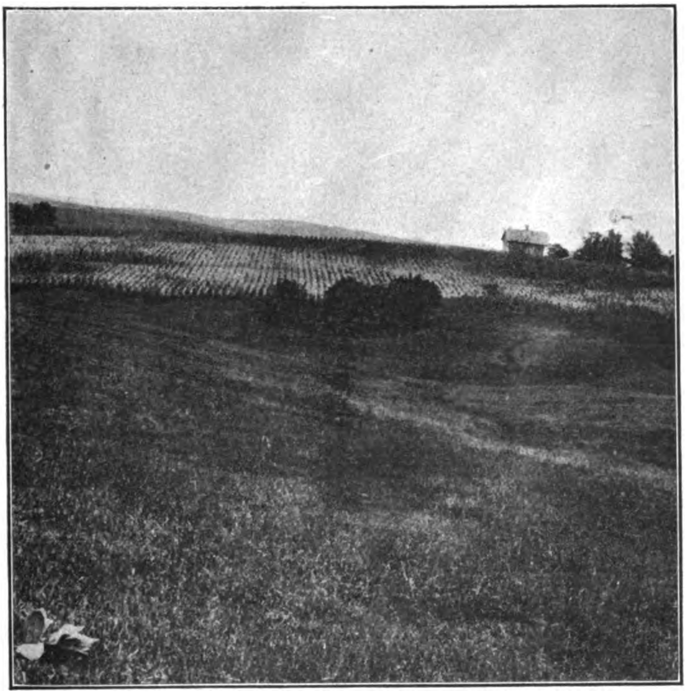

FIG. 4.—A 60-acre cornfield completely destroyed by white grubs, Farmersburg, Iowa, 1912. (Original.)

dant and injurious species in those localities is uniformly three years. We may, therefore, be reasonably certain that in 1914 the beetles will again be unusually abundant, and the year following (1915) the grubs will as a consequence be exceedingly abundant and destructive unless their numbers are materially reduced by natural enemies, by artificial means, or by adverse climatic conditions.

LIFE HISTORY AND HABITS.

Our knowledge of the life histories of the white grubs of the genus Lachnosterna is very meager. There is only one published record, involving a single species, in which an individual belonging to this genus has been reared from egg to adult. In the case of this species (*L. arcuata* Smith) the life cycle in the latitude of Washington, D. C., proved to be three years.[1] From observations reported by Forbes, and from our own observations and rearing experiments, it appears quite certain that in the Northern States the total life cycle of the more injurious species is three years. However, in the case of *L. tristis* Fab., a small species, and one which we have recently reared from egg to adult, the life cycle is only two years. Mr. W. R. Dickeson, of Austin, Tex., writing of the damage by *L. farcta* Lec., says, "One year the grub bothers us and the next year the May beetle," which is circumstantial evidence that this species has only a 2-year cycle in Texas. The total life cycle in all the species occurring in the Southern States may be only one or two years, and in the central

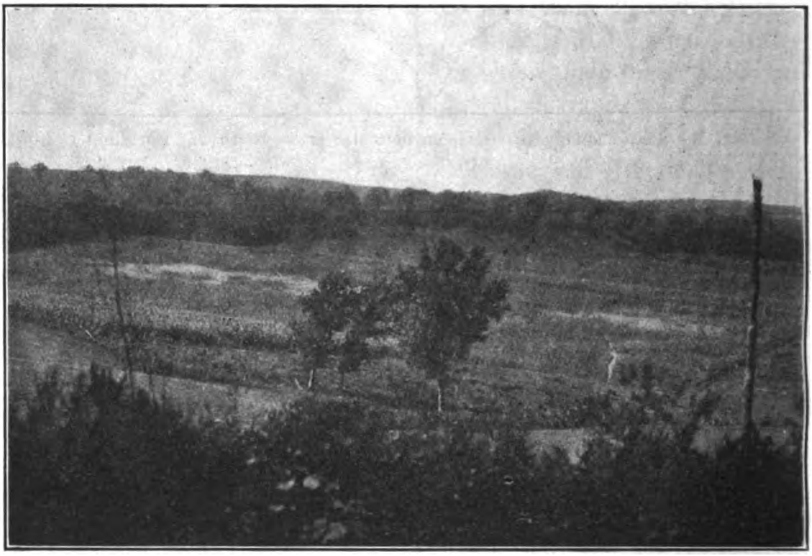

FIG. 5.—A cornfield showing characteristic injury by white grubs, Lynxville, Wis., 1912. (Original.)

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[1] U. S. Dept. Agr., Div. Ent., Bul. 19, n. ser., p. 77, 1899.

parts of Canada it may possibly extend over a period of four years, for such is the variation of the life cycle in the closely related European white grub,[1] which has a 4-year cycle in northern Germany but only a 3-year one in southern Germany.

A résumé of the life of the injurious generation of 1912 is as follows: Eggs (fig. 7) deposited by the female beetle in the spring of 1911 hatched a few weeks later, and the young grubs fed the first season on decaying and living vegetable matter in the soil. As winter approached they protected themselves from the cold by burrowing deeper into the ground, remaining there inactive until the spring of the following year (1912), when they returned to a position near the surface, feeding on the roots of such crops as were available. In this the second year they did the maximum amount of damage. In the fall they again went deep into the soil, to return near to the surface in the spring of 1913, where they will feed as before on the plant roots until about June. They will then prepare oval pupal cells in the ground, become more or less inactive, and later change to the pupal or true dormant stage. The adult beetles, which will emerge from the pupæ a few weeks later, will remain in the pupal cells over winter and will emerge the following spring (1914) to feed and mate in the foliage of trees and shrubs and to deposit their eggs in the soil for another generation.

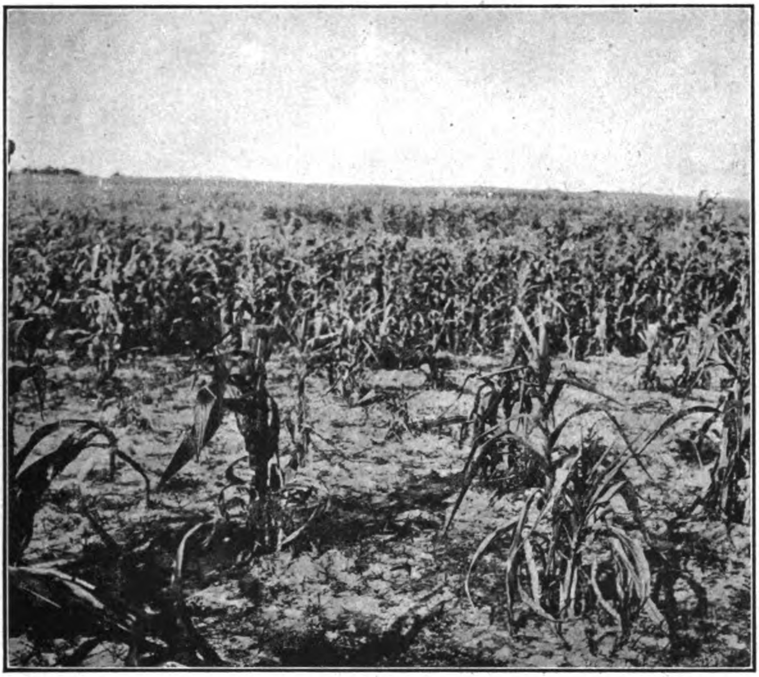

FIG. 6.—A cornfield injured by white grubs, Galena, Ill., 1912. (Original.)

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[1] *Melolontha vulgaris* L.

Unlike the grubs, the different species when in the beetle stage have as a rule different food preferences. Certain species feed almost exclusively on the oak, others prefer the ash, some feed indiscriminately, etc. The trees which the beetles ordinarily frequent at La Fayette, Ind., are the ash, oak, poplar, elm, willow, locust, soft maple, and hackberry. In certain localities the pine seems to be the preferred food. Mr. H. P. Loding reports that in the vicinity of Mobile, Ala., he has collected *L. prununculina* Burm. and *L. micans* Knoch feeding on the longleaf pine, which indeed appears to be their favorite and in some cases possibly their sole food.

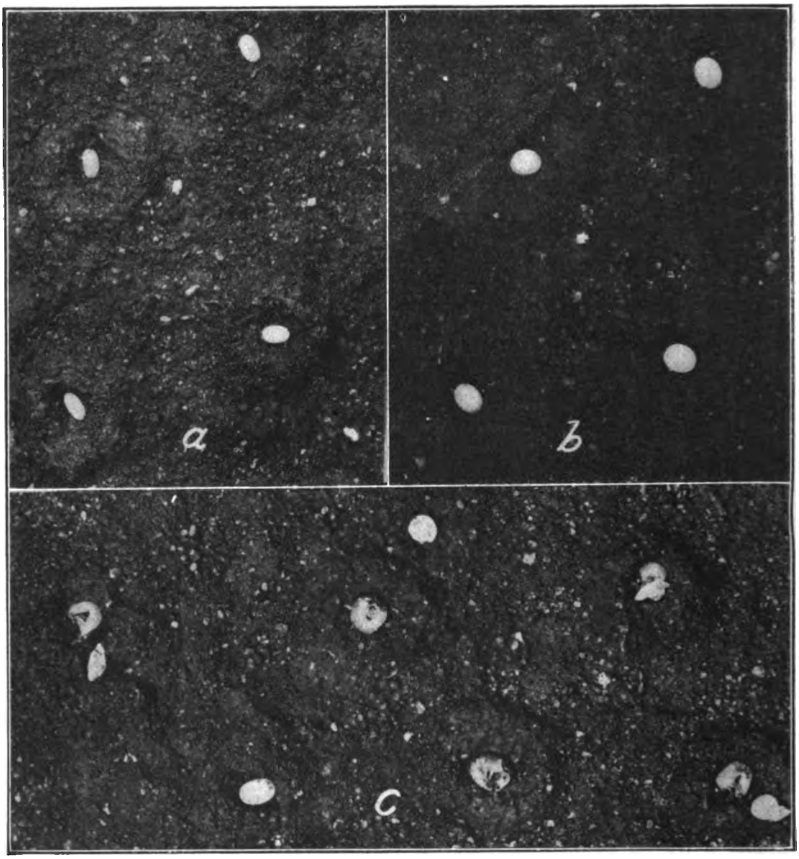

Fig. 7.—Eggs of white grubs in their natural cells: *a*. Immediately after deposition; *b*, six or seven days later; *c*, white grubs hatching. (Original.)

In the latitude of Indiana the beetles make their first appearance the last of April or first of May and continue to be present until the first or middle of July, the period of greatest abundance being between the middle and last of May. They swarm to the trees at dusk and remain there feeding and mating till just before dawn, when they return to the soil, only to reappear the following evening.

When abundant the beetles are capable of defoliating large acreages of timber, often resulting in the death of many of the trees thus attacked. In 1911, 40-acre tracts of timber were completely defoliated by the beetles in southwestern Wisconsin. According to witnesses, the dropping of excrement and of detached leaves at night, when the beetles were feeding, sounded like hail. The following year, 1912, numbers of dead and dying trees were observed in these timber tracts, their death in most cases doubtless resulting from the loss of foliage the year before.

Not only do the different species have individual food preferences, but they also differ in the dates of emergence, some appearing early and remaining throughout the season, others appearing about midseason and remaining only a few weeks. Some species, also, occur only at the higher elevations, while others appear to be common only at the lower levels; but whether this difference is due to a difference of elevation or to the character of the flora, or to a combination of the two, has not as yet been determined.

The beetles (fig. 2) prefer to deposit their eggs in ground covered with vegetation, in the immediate vicinity of timber, usually choosing for this purpose the more elevated parts. For these reasons the grubs are ordinarily found most abundant in the higher portions, especially near wooded tracts, of fields of timothy (fig. 8), blue-grass sod, and small grains, or in any ground which during the previous year was in one or another of these crops.

The eggs (fig. 7, *a*, *b*, *c*) are pearly white and when first laid are elongate, measuring about one-tenth inch in length, but six or seven days after oviposition they become swollen and almost spherical. They are deposited in the soil at a depth ranging from 1 to 8 inches, within oval cavities in the center of balls of earth, the particles of earth forming the balls being held together by a glutinous secretion supplied by the female beetle.

The very young grubs seem to prefer decaying vegetation, although under certain conditions, especially when they are very numerous, they will attack living roots, as was the case in Wisconsin in 1911 when the young grubs damaged timothy fields (fig. 8). As might be expected, the grubs do the greatest amount of damage in their second year and to the early plantings in their third year. While grubs show a preference for certain food plants, from our present data the grubs of different species do not appear necessarily to have different food habits. We have no authentic records of injury to such crops as clover, alfalfa, and buckwheat, and from all observations small grains are less attacked and injured than are corn, timothy, strawberries, and potatoes.

GRUBS LIKELY TO BE MISTAKEN FOR COMMON WHITE GRUBS.

It is important that the grubs of May beetles should not be confused with similar but noninjurious grubs and with such other grubs as may be injurious but which, because of their different habits and life history, necessitate different methods for their control. Probably the most universal mistake is the general belief that the common white grubs of the field and the white grubs found in manure heaps and rotten logs are identical. The grubs of May beetles are not known to breed in manure or refuse of any kind. The most common grubs found in manure are the immature forms of certain brown beetles[1] which, like the May beetles, frequent lights, and would doubtless be mistaken for the latter by an inexperienced person.

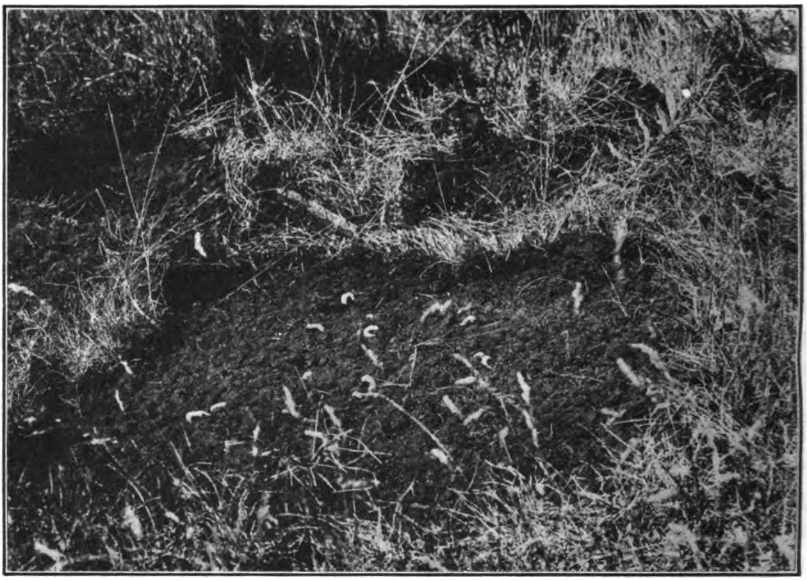

FIG. 8.—A piece of sod overturned to show the white grubs underneath, Lancaster, Wis., 1912. (Original.)

Another grub commonly mistaken for a grub of a May beetle is that of the southern green June beetle,[2] which has frequently been reported as injuring grass and other vegetation in localities south of latitude 39°, or even farther north along the Atlantic coast. The grub of the green June beetle seems to prefer soils more or less heavily fertilized with manures, and besides, entirely unlike the common white grubs, it makes definite burrows which usually open at the surface and which it may inhabit continuously for longer or shorter periods of time. For this reason grubs of this species will come to the entrance of their burrows and even crawl out upon the ground when the land is flooded with water. This characteristic also offers us a satisfactory means of controlling the grub of the green June beetle when in lawns or small areas. (See p. 20.) Again, this grub may be distinguished from the true white grubs by its general appearance, and especially by its peculiar and characteristic method of crawling on its back when placed on the surface of the ground.

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[1] *Ligyrus gibbosus* De G. and *L. relictus* Say.

[2] *Allorhina nitida* L.

NATURAL ENEMIES.

The white grubs and May beetles are preyed upon by numerous birds, mammals, and insects, all of which are more or less useful in reducing their numbers. Probably the most important of these enemies are the birds, especially crows and crow blackbirds. Fields of timothy sod have been literally overturned by crows in their search for grubs (see fig. 9), and in some fields the grubs were almost exterminated by them. Crows have often been observed following the plow in infested fields, eagerly picking up every grub that was unearthed. Mr. Henry Holzinger, of Lancaster, Wis., said that crow blackbirds followed the plow in great numbers where he was turning over a sod field in the spring of 1912. In one instance he watched a single blackbird eat many grubs, apparently its full capacity, and then gather as many as it could hold in its beak and fly away. In this case the bird destroyed in all 20 grubs in about 1 or 2 minutes. This habit of eating a large number of grubs and then flying away with its beak full was reported as a common occurrence with the blackbird. Mr. Fred Nelson, of Tabor, S. Dak.,

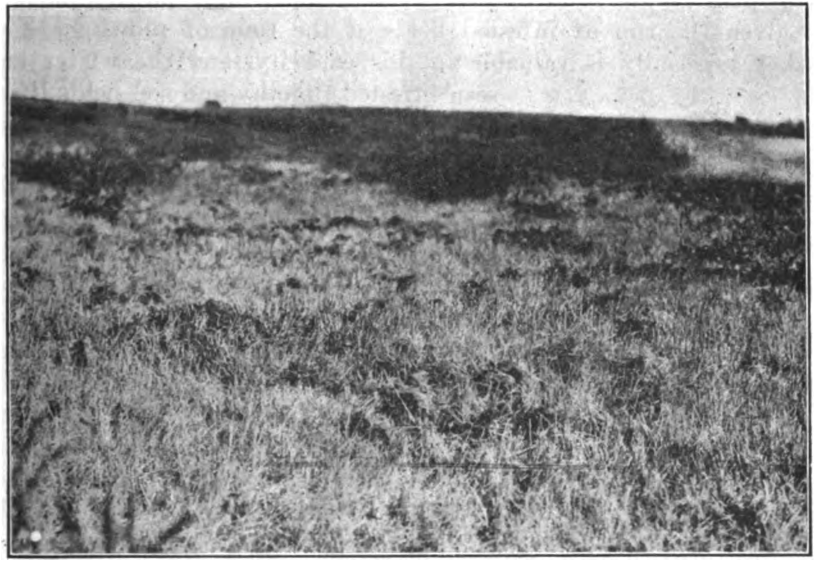

FIG. 9.—Timothy field after harvest, showing sod overturned by crows in their search for white grubs, Galena, Ill., 1912. (Original.)

stated that his attention was directed to the unusual abundance of grubs in his field in the fall of 1911 by the blackbirds which came in flocks and followed him as he plowed. He soon learned that they were gathering grubs. After picking up several grubs each bird would fly back to the trees a short distance away and soon return. Thus there was a continuous flight from the trees to the ground and from the ground to the trees. Besides crows and blackbirds practically all of our common birds feed on white grubs or their adult forms, the May beetles. The Biological Survey has found these insects in the stomachs of more than 60 species of birds.

Domestic fowls may properly be classed as natural enemies of white grubs, although their usefulness is largely controllable. All farm poultry are fond of these insects, and where possible should be given the run of infested fields at the time of plowing. The turkey especially is valuable in this capacity, and the writer has seen infested timothy and sod fields literally overturned by these birds in their search for grubs.

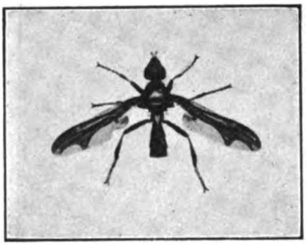

FIG. 10.—*Pyrgota undata*, a fly parasite of May beetles. Natural size. (Original.)

Among the undomesticated mammals which feed on the grubs the skunk, or so-called polecat, is probably the most valuable,[1] and, indeed, some farmers have gone so far as to attribute the increase in these insects to the decrease in numbers of the skunks, which are being rapidly killed off by trappers. In a field of winter wheat at Lagro, Ind., the grubs were reported cutting off the young wheat plants, and when the fields were examined a few days later (November 3, 1911) a skunk hole 3 to 5 inches in depth was found at nearly every stool of wheat which had been attacked by the grubs, and in every case the animal had invariably captured the culprit. In northeastern Iowa many large landowners observed the grub-eating habits of the skunk during the recent severe outbreak, and have signified their intention from now on of protecting this friend of the farmer. Innumerable instances of this nature illustrating the value of skunks could be cited.

A number of predaceous and parasitic insects have been reported as attacking the grubs and May beetles. and of these enemies it is probable that such common and generally distributed forms as the black digger wasp, *Tiphia inornata* Say, and another wasp, *Elis sexcincta* Fab.. both of which attack the grub, together with a fly, *Pyrgota undata* (fig. 10), which attacks the adult beetle, are the most beneficial. The Tiphia larva, after devouring the grub, forms a characteristic cylindrical-ovate, light brown, woolly cocoon about three-fourths inch in length (fig. 11, *b*), and from this the jet black digger wasp emerges the following spring. It in turn mates, and the female reenters the soil and there deposits its eggs on the grub, usually fastening them on the back of the latter just behind the head. The Elis cocoon (fig. 11, *a*) differs from the Tiphia cocoon (fig. 11, *b*) in that it is elliptical, slightly longer, and comparatively smooth. The adult emerging therefrom is about the same size as the Tiphia wasp, or slightly larger, and the black abdomen is transversely striped with yellow. The cocoons of both of these parasites are frequently turned out by the plow, especially in fields badly infested with white grubs. The parasitic fly *Pyrgota undata* Wied.[1] (fig. 10) attacks only the beetle, usually depositing its egg within the body of the beetle as the latter flies from leaf to leaf or to the ground at night. The larvæ hatching from these eggs gradually kill the beetle, although as a rule the latter, if a female, is capable of copulating and of depositing eggs for some days after being parasitized; consequently this parasite may not be so valuable as might at first be anticipated.

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[1] The domestic hog is the most efficient of all grub destroyers where it can be utilized. It is fully discussed in this connection under "Methods of control," p. 16.

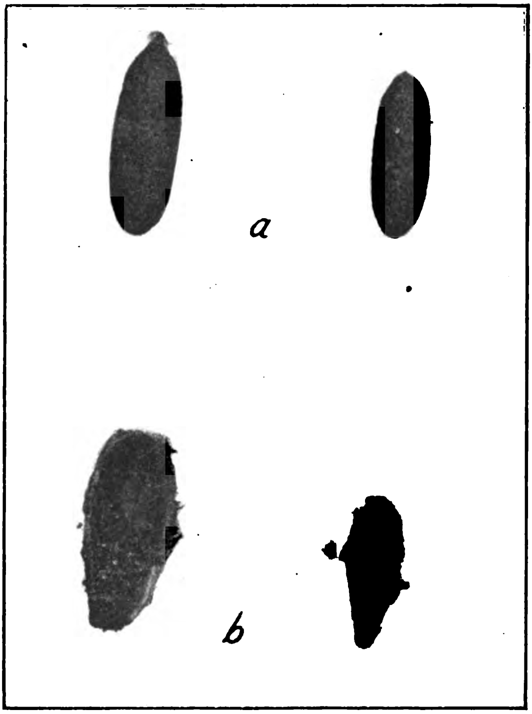

FIG. 11.—Cocoons of wasps that prey on white grubs: *a*, *Elis sexcincta*; *b*, *Tiphia inornata*. Natural size. (Original.)

Several fungous and bacterial diseases have been reported attacking the grubs and beetles, but the knowledge of these is as yet superficial. Occasional outbreaks of these diseases have been reported, and it is highly probable that they serve as valuable natural checks. In Europe certain of these diseases have been artificially grown and used to destroy the grub, but there seems to be a divergence of opinion as to their value when used in this manner, and the feasibility of their use for this purpose is still an open question.

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[1] It has been found that another species of Pyrgota (*P. valida* Harr.) is parasitic on the beetles, and this species may prove to be equally as important as *P. undata*.

METHODS OF CONTROL.

All general measures here discussed and recommended are preventive rather than remedial, for once white grubs are present in a field of corn or other crop there is no means as yet known of protecting that particular crop from its ravages. On the other hand, there are certain cultural and other practices which will greatly minimize the damage in succeeding years.

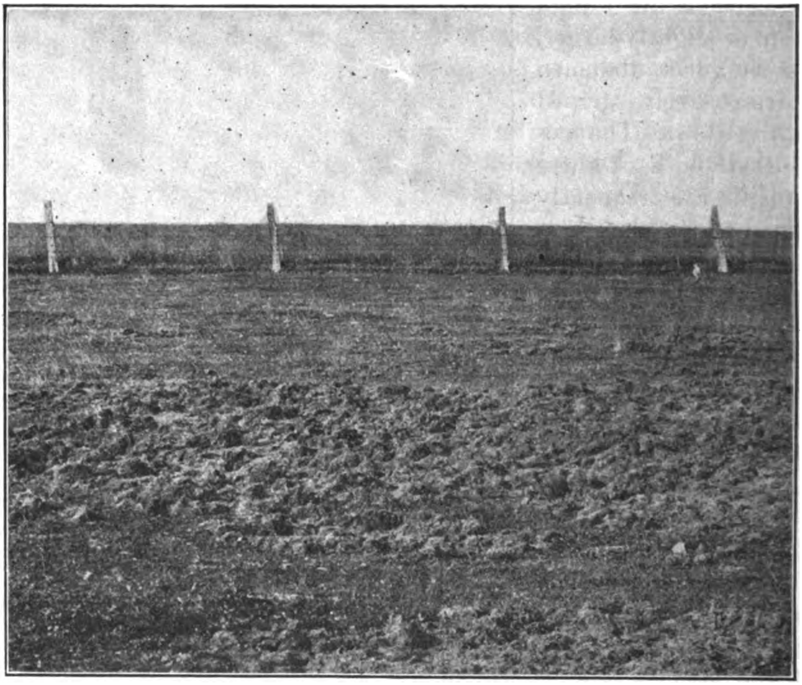

FIG. 12.—Pasture sod overturned by swine in their search for white grubs, Lancaster, Wis., 1911. (Original.)

UTILIZING HOGS AND POULTRY FOR DESTROYING THE GRUBS.

An infested field may be thoroughly cleared of grubs by pasturing it with hogs, and this method should be followed wherever possible. Hogs are very fond of grubs and will root to a depth of a foot or more in search of them. (See fig. 12.) Such pasturing may be done at any time during the summer, but it should not be delayed later than the middle of October nor should it be practiced earlier in spring than April in the latitude of central Indiana or May in the latitude of Wisconsin, since at other times the grubs will probably be in their winter quarters, deep in the ground, and a large percentage may then escape the hogs.

It should be noted here that the giant thorn-headed worm,[1] an intestinal worm attacking swine, passes one of the early stages of its life within the white grub, and hogs become infested with these worms by feeding on infested grubs. The grubs in turn become infested through the excrement of infested swine. In the grub-infested localities of Iowa, Illinois, and Wisconsin visited by the writer this intestinal worm is quite prevalent, but inasmuch as most of the swine in these regions are slaughtered before they are 1 year old the prevalence of the worms in this region is of little if any importance. Precautions should be taken, however, to protect the animals from infestation where possible. In this connection Dr. S. A. Forbes says:[2]

> Pigs which have never been pastured are certain to be free from these parasites, and grubs growing in fields which have not been pastured by pigs are likewise certain to be free from them. The use of such pigs upon such fields would consequently be without danger from this source, and a little attention to these facts will avoid any injurious consequences. That is, if pigs not previously allowed to run out are turned into fields on which pigs have not been pastured within three years, there will be no danger that they will become infested by these thorn-headed worms.[1]

In 1912 the writer observed a field in which half of the corn was uninjured and free from grubs, while the other half was badly damaged. The previous year both halves of this field had been in timothy, but with this difference: The half where the injury occurred was left for hay and the other half was fenced off and pastured with dairy cows. The only plausible explanation seems to be that the trampling of the ground by the cows killed the eggs and grubs in the field, or else that the ground had been trampled sufficiently previous to the flight of the beetles to prevent them from entering the soil and laying eggs.

Domestic fowls should be given the run of infested fields, and especially when the land is being plowed, for they are very fond of grubs and will destroy large numbers.

During the years of great abundance of the beetles hogs should be turned into orchards and timber lots during the period of flight (May and June), since a majority of the beetles pass the day just below the surface of the soil beneath or near the trees upon which they have been feeding the night before, and will be eagerly sought and eaten by the hogs.

FALL PLOWING.

Where it is impracticable to pasture hogs in an infested field much good can be accomplished by plowing the land in the fall. The plowing should be done late in fall, but, on the other hand, it should not be delayed until cold weather sets in or until the ground becomes chilled and frosty, for then the grubs will have gone down to their winter quarters beyond the reach of the plow. Ordinarily the best time to plow is between October 1 and October 15. *In 1913 deep plowing at any time in the fall, especially in early fall, will be of special value in those regions where the grubs were so destructive in 1912, since the grubs will then have changed to pupæ and adult beetles, and these will be destroyed if the pupal cells in which they pass the winter are disturbed.*

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[1] *Echinorhynchus gigas.*

[2] Forbes, S. A. On the life history, habits, and economic relations of the white grubs and May beetles (Lachnosterna). Ill. Agr. Exp. Sta., Bul. 116, p. 479, August, 1907.

ROTATION OF CROPS.

Since the beetles usually deposit their eggs in fields of grass, timothy, and small grains, the crops planted in these fields the year following a season of beetle abundance should be those which are the least susceptible to grub injury, such as small grains, buckwheat, clover, alfalfa, and peas. Care should always be exercised in the selection of a crop to follow sod or old timothy ground, even though the beetles were not noticed as especially abundant the preceding year. Where hogs can be pastured on the land the fall or spring previous to planting, as discussed in another paragraph, the grubs will be practically eliminated.

COLLECTING THE GRUBS AND BEETLES.

Where it is possible to secure cheap labor, collecting the grubs after the plow is practicable, especially where the grubs are numerous. In Europe children are often employed to gather grubs in this manner and to collect the beetles as described below.

Collecting the cockchafer or Maikäfer, a beetle very closely related to the May beetle, is a common practice in European countries, but so far as known the attempt to collect May beetles on an extensive scale in the United States has never been made. Three methods may be employed in beetle destruction: (1) Collecting from plants upon which they feed at night, (2) trapping at lights, and (3) poisoning their food plants.

In Europe beetle collecting has proved of value largely because the years of abundance of the beetles have been definitely known in advance, while in America this has not been the case. Now, however, there is proof that the beetles occurring in such abundance in many parts of the United States in 1911 (the parents of the destructive generation of grubs in 1912) have a life cycle of three years, and it is reasonably certain that they will continue to be exceptionally abundant in these regions every three years unless killed off by their natural enemies, by artificial means, or by unfavorable climatic conditions. Beetle collecting in the Old World has also proved practicable, first, because of the organized cooperative movement by the farmers for the collection of the beetles; second, because a small bounty is paid for the beetles; and, third, because of laws which in some countries require each farmer to collect a certain quantity of the grubs or beetles each year. Individual action is useless, and only where whole communities or neighborhoods cooperate in the work is it effective.

In collecting from food plants large cloth sheets are placed under the tree and the latter jarred, or in the case of large trees individual branches may be shaken by using a long pole provided with a hook at the end. The beetles are then gathered up from the sheet and placed in cans, bottles, or boxes and afterwards killed with carbon bisulphid. Killed in this manner they may be fed to chickens, pigs, etc., but if they are not to be used for such purposes they may be killed by dropping them in cans containing water and just enough kerosene oil to cover the surface. Different species have different food preferences, but as a rule beetles are most abundant on the oak, walnut, poplar, hackberry, willow, ash, and elm. Collections may be made at any time during the night, but the best time for this work is in the early morning, before 4.30 o'clock, at a time when the beetles are easily jarred from the foliage. It is essential that collecting be begun as soon as the beetles appear in the spring—that is, before the beetles have begun to lay their eggs—and it should also be borne in mind that each female beetle destroyed early in the season means the destruction of from 50 to 100 grubs which she might have produced.

Light traps have not as yet proven satisfactory as a means of control against May beetles, the prime objection to this method being that the light attracts the males to the almost total exclusion of the females. Further tests with this method must be made, and it is possible that the light may prove attractive to the female beetles in years of unusual abundance if placed close to the trees or shrubs upon which they feed.

SPRAYING.

Spraying trees upon which the beetles feed, with Paris green or arsenate of lead, is effective against the beetles, but ordinarily this method is impracticable owing to the large size of the trees, which would necessitate large and expensive power sprayers. With a more definite knowledge of the preferred food plants, it may be found practicable in some localities to plant low-growing trees and shrubs about fields as traps for the beetles, which might then be destroyed by spraying.

SPECIAL DIRECTIONS.

In those regions in which the grubs were so abundant and destructive in 1912 certain special directions and precautions may prevent a repetition of the damage in 1915. As has already been stated, the parents of the grubs of 1912 appeared in the spring of 1911 and laid the eggs which hatched into the grubs. Practically no damage occurred that year, but in 1912, when about half grown, the grubs caused great loss. These grubs will continue active in the spring of 1913 and may injure certain early plantings, but by early June most of the grubs will have become more or less inactive and later will change to the dormant or pupal stage, transforming to beetles about August. They will remain in the soil as beetles over winter, appearing above ground in the spring of 1914. Small grain may, with comparatively safety, be planted in 1913 on land infested in 1912. If infested ground must be utilized for corn, potatoes, or other susceptible crops in 1913, planting should be delayed as long as possible, in which case injury will be minimized or may be wholly prevented. In 1914 a maximum acreage of such crops as corn and potatoes should be planted, and these should be kept thoroughly cultivated during the flight of the beetles. Land which is planted to small grain, timothy, and other crops which cover the ground with vegetation at the time of the flight of beetles should be planted in fields farthest from trees, and such fields should be planted the following year (1915) to crops least susceptible to white-grub injury, such as clover, alfalfa, small grains, and buckwheat. In addition, the methods which have already been discussed, namely, the use of hogs and domestic fowls, fall plowing, and the gathering of beetles and grubs, should be practiced.

IN THE LAWN.

No reliable remedy can be offered for the destruction of grubs in lawns. Where possible, poultry, especially turkeys, should be allowed the run of the infested area. Hogs will of course rid the ground of grubs, but they will likewise tear up the sod and are not usually desirable in cities. When badly infested, the removal of sod and the gathering of the grubs by hand, and later, fall plowing, will probably prove satisfactory. If the infestation is not severe, liberal applications of commercial fertilizer will assist the grass in overcoming the grub injury. It has been demonstrated in Europe by Decoppet[1] that carbon bisulphid injected into the soil at a depth not exceeding 6 inches, at the rate of 1 to 1¼ ounces in six or eight holes per square yard, will considerably diminish the number of grubs. Decoppet experimented with an European white grub,[2] and it appears quite probable that this method would prove satisfactory for our white grubs when they appear in lawns. It might be mentioned here that carbon bisulphid may be injected with excellent results into the holes of the grub of the southern green June beetle, which is frequently quite destructive to lawns in the Southern States. In using carbon bisulphid care should be exercised never to permit a spark of fire to come near it, for it is extremely inflammable, and its vapor, mixed with air, is explosive. Holes in which the carbon bisulphid is injected should be closed with a plug of soil or sod immediately after the injection, to prevent the escape of the fumes.

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[1] Bul. Soc. Vaud. Sci. Nat., 5me ser., t. 48, no. 176, pp. xxxv–xxxvi, June, 1912. Abstr. in Internat. Inst. Agr. (Rome), Bul. Bur. Agr. Intel. and Plant Diseases, vol. 3, no. 6, pp. 1456–1457, 1912, and in U. S. Dept. Agr., Experiment Station Record, vol. 27, no. 7, pp. 661–662, 1912.

[2] *Melolontha* sp.

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Issued June 25, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 544.

POTATO-TUBER DISEASES.

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BY

W. A. ORTON,

*Pathologist in Charge of Cotton and Truck Disease
and Sugar-Plant Investigations.*

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., April 10, 1913.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a manuscript entitled "Potato-Tuber Diseases," by Mr. W. A. Orton, Pathologist in Charge of Cotton and Truck Disease and Sugar-Plant Investigations.

The increasing prevalence of potato diseases and the extent to which these are carried over on seed makes it desirable to present information regarding methods of control as a basis for a campaign for the use of disease-free seed potatoes.

Respectfully,

Wm. A. Taylor,
Chief of Bureau.

Hon. D. F. Houston,
Secretary of Agriculture.

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POTATO-TUBER DISEASES.

INTRODUCTION.

The average yield per acre of potatoes in the United States is not more than half what might reasonably be expected. This shortage is attributable to a variety of causes, including numerous diseases, a lack of well-adapted varieties, failure to fertilize liberally and to cultivate intensively, and neglect of crop rotations. The fact that in several States the long, hot summers are unfavorable for potato culture also tends to lower the average production of the country.

Potato diseases constitute an exceedingly important factor in American potato culture and require every grower who aims toward a high standard to exercise the closest watchfulness, not only at the time of planting and throughout the growing season, but at the harvest and during the winter storage. The use of disease-infected seed is one of the principal causes of failure to germinate, and poor stands are responsible for many low yields; other diseases introduced in seed injure or kill the growing plants; scabby, deformed, or otherwise affected potatoes bring a lower price in the market; losses in storage or in transit result from infections by decay-producing organisms. New troubles are constantly being introduced from foreign countries on imported potatoes. They effect a lodgment in one of our seed-producing districts and are thence distributed to all parts of the country. Our soils thus become infected and are permanently or for several years thereafter rendered less suitable for potato production.

At no time is there a better opportunity to improve the quality and increase the quantity of the potato crop through prevention of disease than before planting. This bulletin directs attention particularly to those troubles affecting the tubers or carried on them which should be taken into consideration in selecting the seed stock for planting.

There are peculiar conditions in the United States which make this a subject of wide and general interest. A large part of our territory lying in the Southern, South-Central, and Western States secures better results from planting seed potatoes grown near our northern border in Maine, New York, Minnesota, etc., than from home-grown stock. There has consequently grown up a large trade in potatoes which are annually shipped long distances for planting.

Furthermore, there is taking place a constant extension of potato culture into districts where this crop has not previously been grown. This development is most notable in the newly irrigated parts of the West, in the recently deforested portions of Minnesota, Wisconsin, and Michigan, and in the trucking districts of the Gulf States. In each case the seed supply has to be brought from outside, and in far too many cases no attention is paid to the elimination of disease. That it might be practicable to keep these new soils free from infection by rigid exclusion of diseased stock is not realized in time. Few growers and few communities profit from the experience of others, but must be convinced by personal losses. The opportunity of keeping a district free from infection will not come again, for most diseases remain for considerable periods in the soil and are not easily exterminated. Furthermore, the principal potato troubles have already been widely disseminated.

The responsibility of seed dealers in this matter is large. The interest of the local dealer in the continued maintenance of productivity of a region is as great as the farmer's, and few of them would knowingly risk the introduction of pests that might threaten the prosperity of their section, yet through lack of foresight and knowledge this has often been done.

THE PRINCIPAL DISEASES AND THEIR CONTROL.

There are several minor diseases of the potato tuber that are not discussed in this bulletin. Some insect injuries, also, are not infrequently confused with the diseases, but, in the main, the troubles which the potato grower should know and watch for in selecting seed are included. No attempt has been made to treat each trouble fully or to give technical details, but a description has been given, which, taken in connection with the illustrations, should make the recognition of each disease a simple matter. The most successful means of control are outlined. At the end of the bulletin (p. 14) is a general discussion of seed inspection, disinfection, and methods of growing and distributing healthy seed potatoes.

DISEASES AFFECTING THE SKIN OF THE TUBER.

More or less superficial injuries are caused by several scab organisms, parasites of the periderm and outer layers. A discussion of the most important follows.

Common Scab.

Common scab, a widely prevalent and familiar disease, is caused by a parasitic organism previously considered a low type of fungus (*Oospora scabies* Thax.), though more recent work indicates that it is more closely related to certain soil-inhabiting bacteria. It produces rough, scabby, or pitted spots on the potato (fig. 1), which may spread and cover the whole tuber. They are sometimes made deeper through the work of small insects. Beets and turnips are also occasionally attacked.

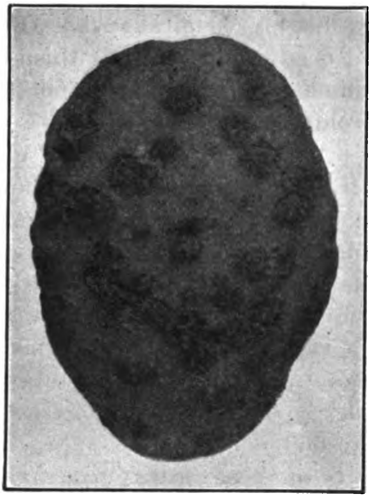

Fig. 1.—A potato affected with common scab.

This parasite appears to be present in many soils and to be able to live there for years, particularly if the land is not acid. It is believed that the planting of infected potatoes is the chief agency of spread. It is therefore recommended that all seed stock be disinfected before planting by soaking two hours in a solution of formaldehyde (1 pint to 30 gallons of water). This treatment should be given whether any scab is detected or not, as the infection may nevertheless be present. Slightly scabby potatoes are not objectionable for planting if disinfected, but very scabby ones are usually rejected, as the eyes may be affected. Treatment of seed will not be sufficient if the soil is infected with the scab fungus; a long rotation of other crops then becomes necessary.

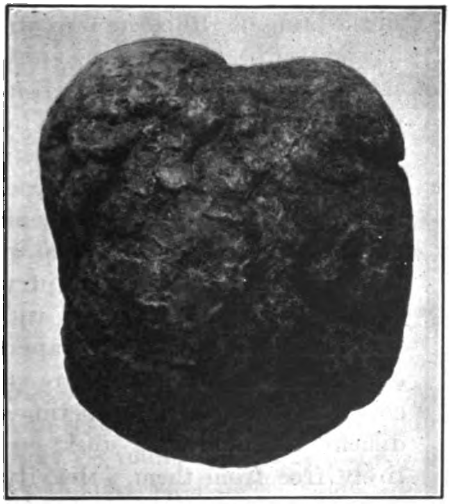

Fig. 2.—A potato affected with russet scab, showing the russeting and cracking, associated with the fungus Rhizoctonia, of a western potato.

Scab requires a neutral or alkaline soil reaction for its best development. It does not occur on distinctly acid soils unless an alkaline fertilizer is used. Lime, fresh stable manure, and wood ashes all promote scab, so these materials should not be used on the potato crop. Whether they can be applied to another crop in the rotation depends upon the degree of acidity present, which can be ascertained only by actual field experiments or by having the lime requirements of the particular field in question determined by chemical tests. If used at all, it is advisable to apply them to the crop immediately following potatoes in the rotation system.

Acid soils may yield clean crops from scabby seed, but if they are later made alkaline by lime or manure scab may develop. The use of commercial fertilizers, especially those containing chlorids, such as kainit or muriate of potash, tends to bring about an acid condition of the soil. Plowing under green crops like rye has been recommended as an expedient for reducing scab injury in infected soils, but experiments have shown that this is not always effective.

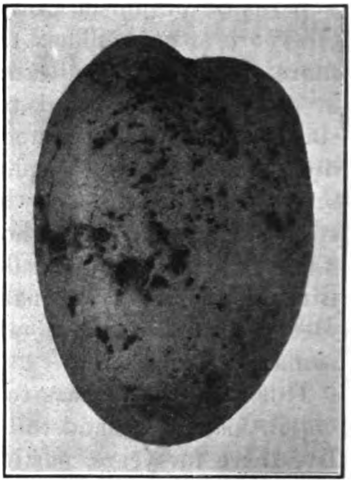
FIG. 3.—Black resting bodies, or sclerotia, of Rhizoctonia on a potato.

Russet Scab.

A second form of scab, or russeting, on potatoes, which is common in the West, is shown in figure 2. This is attributed to the sterile fungus Rhizoctonia, but has not yet been well worked out. It often occurs in association with the common scab. The fungus is conspicuous for its brown mycelial strands and black sclerotia, which appear on the outside of the tuber, as in figure 3, where no direct injury to the potato has resulted and the black bodies can be scraped off. Such fungous masses are so common that it is sometimes difficult to find seed stock entirely free from them. Heavily spotted potatoes should not be planted. A second stage of this fungus occurs as a white, felty covering on the bases of potato stalks in late summer.

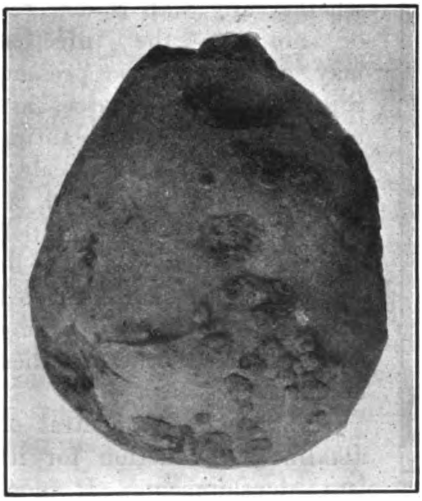
FIG. 4.—A potato affected with powdery scab.

This fungus appears to act as a parasite mainly in heavy, poorly aerated, or overirrigated soils. It is the cause of seedling troubles of many plants, including cotton, beets, and beans, and may cause lesions on the potato stem at the soil line and below. If girdled, the plant forms numerous aerial potatoes. If the lesions are on the stolons the small potatoes are cut off, and large vines with small and few tubers result. This trouble is more common in irrigated districts than in the East.

This disease is not to be combated by seed disinfection, as the black sclerotia of the fungus are not killed by the ordinary formaldehyde treatment. Selections of lighter types of soil, rotation of crops to add humus, and deep preparation and culture to maintain a good physical condition of the soil are important.

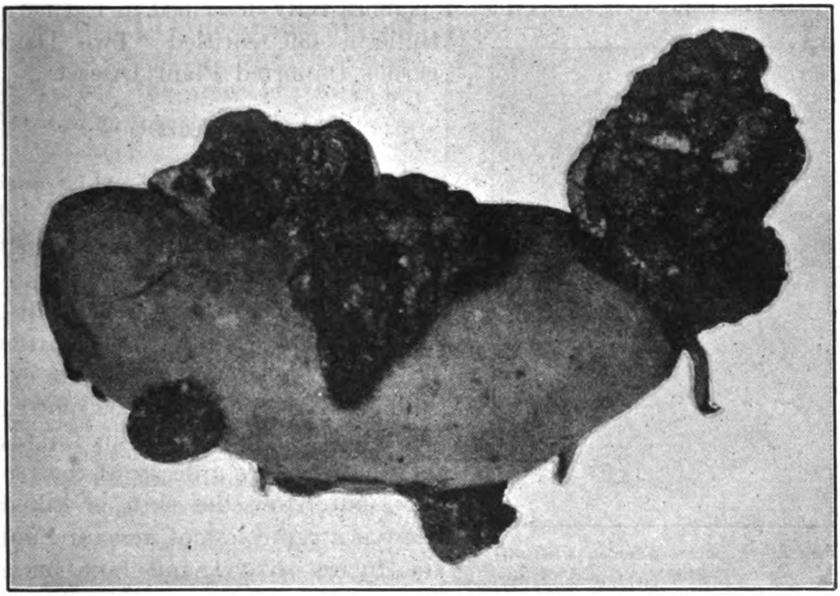

FIG. 5.—A potato affected with potato wart. (From Journal of Board of Agriculture.)

Powdery Scab.

Powdery scab, a new type caused by a parasite (*Spongospora solani* Brunch.) quite different from that causing the common American scab, has recently been introduced from Europe into Canada and may be found in this country. This differs from the common scab in the character of the spots, which are first covered and later break out into brown, powdery masses. (Fig. 4.) In many cases this disease forms swellings or excrescences on the tuber. Since it is likely that this will prove to be a quite serious disease it should be carefully watched for and promptly reported.

Potato Wart.

Among threatening diseases not yet introduced, but which should be watched for and reported by American growers, the potato wart (*Synchitrium endobioticum* Perc.)[1] is the most serious. This forms irregular, warty excrescences on the tubers (fig. 5), sometimes entirely destroying them. The importation of potatoes from countries where this disease exists has been prohibited, but, unknown, it may already have gained a foothold somewhere. Any suspected case should be reported. This disease is more fully described in Farmers' Bulletin 489, entitled "Two Dangerous Imported Plant Diseases."

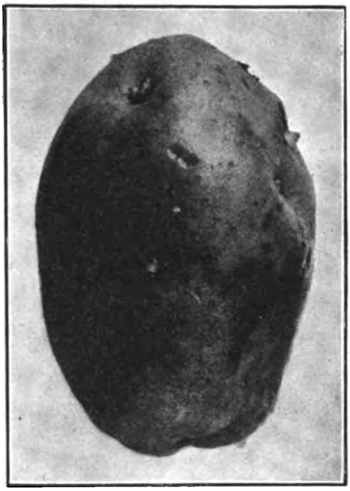

FIG. 6.—A potato affected with silver scurf. The lower part of this tuber is affected; the upper, normal.

Silver Scurf.

A new disease, silver scurf (*Spondylocladium atrovirens* Harz) (fig. 6), has recently been introduced from Europe and is spreading rapidly in our Eastern States. This disease is marked by dark areas on the skin of the tuber, which on close examination may be seen to be spotted with fine black points. This fungus does not produce a decay of the potato, but after the skin is killed there is a rapid loss of moisture and the tubers shrivel and take on a silvery appearance, greatly depreciating their market value. This fungus is apparently not killed by seed disinfection; therefore all infected potatoes must be rejected.

DISEASES OF THE STEM AND VASCULAR SYSTEM.

Black-Leg.

A serious disease of the potato plant, which can be controlled by seed selection and treatment, is black-leg. This is marked by the upward rolling and yellowing of the young or half-grown plants and by the black, shriveled condition of the stem, from the seed piece to above the ground. (Fig. 7.) The cause is a bacterial organism (*Bacillus phytophthorus* Appel and related forms), carried in the seed potatoes. An extreme case of a tuber affected with black-leg is shown in figure 8. Others may show only a browning of the vessels at the stem end.

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[1] This disease is also known as potato canker and black-scab.

Black-leg apparently came to us from Europe. It is spreading in the Northern States, but is of especial consequence to the southern trucker, as it takes a more virulent form in the South. Growers of seed potatoes should take every means to eliminate black-leg from their fields, and southern purchasers should insist that this be done. Dr. W. J. Morse, of the Maine experiment station, in 1911 advised that all bruised and cracked tubers be rejected when planting and that the selected stock be treated as for scab. He said:

> Those who were intending to plant only selected, treated seed were advised to reject all tubers when cutting which showed any discolored areas in the flesh, particularly those which showed browned or blackened rings at the stem end, no matter how slight. As a further precaution it was recommended that extra knives and a jar of formaldehyde solution be provided when cutting seed and if, by chance, a diseased tuber was cut, the knife blade could be dropped into the disinfecting solution for a time and another used in its place.[1]

The seed should not be cut until immediately before planting and must not be allowed to become contaminated after treatment.

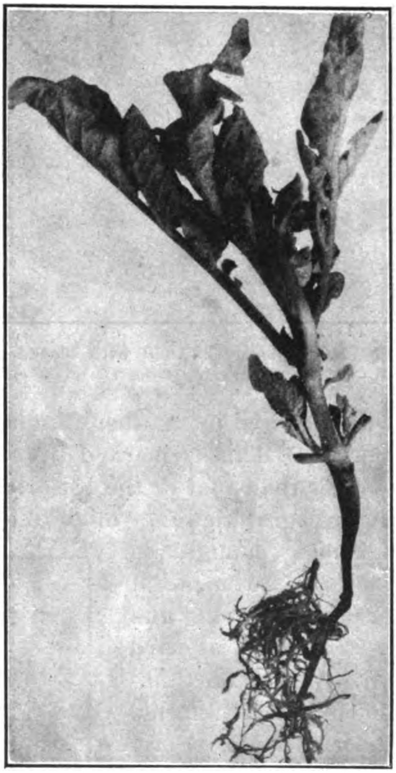

FIG. 7.—A potato plant affected with black-leg in the summer stage, the result of planting diseased tubers. The lower part of the stem is shriveled and black; the leaves are yellow and rolled upward.

Fusarium Wilt.

A brown or black discoloration of the stem end of the tuber when cut across, one-fourth to one-half inch deep, should condemn it for planting. Several diseases infect the stem end in this way, but perhaps the most serious is the Fusarium wilt. Potatoes showing the stem-end discoloration characteristic of this disease are shown in figure 9. The fungus causing this wilt (*Fusarium oxysporum* Schlecht) enters the plant through the small roots and works upward in the wood vessels, which are so filled that a wilting or premature death of the plant results. It overwinters in the tubers and has been widely spread by the use of infected seed, particularly in the Central and Western States, where it has caused great reductions in yield. Potatoes from wilted plants are more subject to the stem-end dry-rot mentioned on page 12. It is advised that no lot of potatoes be planted any material number of which show a deep brown or black discoloration at the stem end. Cases may be cited where such seed gave a satisfactory yield, but the land was thereby infected and in the end will become unproductive from this cause.

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[1] Maine Agricultural Experiment Station Bulletin 194, p. 208, 1911.

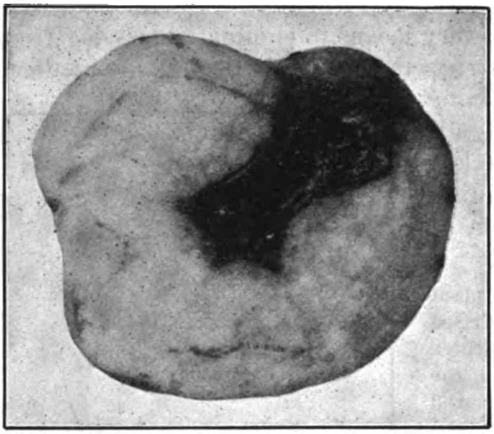

Fig. 8.—A potato affected with black-leg, showing decay starting from the stem end.

Verticillium Wilt.

A wilt disease somewhat similar to Fusarium wilt is caused by another fungus (*Verticillium alboatrum* Reink. and Berth.). This is marked by a stem-end discoloration of the tuber blacker than that of the Fusarium wilt, by a more rapid wilting, and by a geographic range more to the north. The wilted plants are conspicuous enough in the field to make it practicable to dig and destroy the affected hills during the summer. All affected tubers should be rejected for planting.

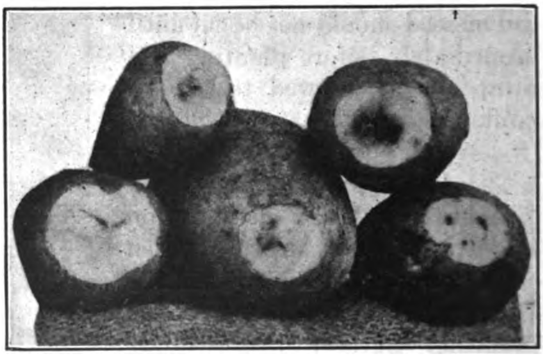

Fig. 9.—Potatoes affected with Fusarium wilt, showing stem-end discoloration of the vascular ring.

Bacterial Wilt.

In the South Atlantic States from Florida to Maryland a bacterial wilt is not infrequent. This parasite (*Bacterium solanacearum* Erw. Sm.) also attacks tomatoes, eggplants, and peppers. The foliage wilts suddenly. The wood vessels of the stem are discolored, and the potato shows a dark ring and usually decays quickly.

(Fig. 10.) When this disease occurs in the fall crop the product should not be used for planting purposes. No other practical method of control has been worked out. Since nearly all the southern crop is grown from seed obtained from northern sources, where bacterial wilt does not occur, the disease is not often a serious factor in commercial potato production.

TUBER ROTS.

Late-Blight Dry-Rot.

One of the most destructive diseases in the New England and North-Central States is the late-blight, due to a fungus (*Phytophthora infestans* De By.) which destroys the foliage in seasons of cool, moist weather. This is followed by a rot, marked by sunken, dark spots on the tuber (fig. 11) and by a brown discoloration of the flesh extending in from the outside (fig. 12). Under storage conditions this is typically a dry-rot, but in the field it more frequently becomes a soft rot, because other organisms follow the late-blight fungus.

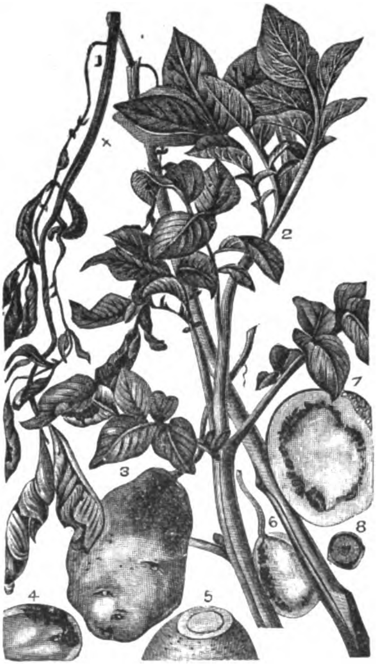

Fig. 10.—Potatoes affected with bacterial wilt, showing wilting of stem and leaves and browning of tubers.

Affected potatoes should be discarded in planting, because they generally fail to germinate. This disease is a common cause of broken stands in potato fields. Late-blight is preventable by thorough spraying during summer and fall with Bordeaux mixture. This spraying should be especially well done on fields intended for seed purposes, for the potatoes become infected with dry-rot by spores from the blighting foliage at or before the harvest. This infection is often not apparent when the potatoes are put in storage, but it develops during the winter unless the temperature of the cellar is kept just above the freezing point. Cool storage is consequently a vital factor in the preservation of seed potatoes in seasons when late-blight is prevalent. The disease may develop on potatoes shipped south in the fall for seed purposes, unless the best of storage conditions are provided.

The presence of late-blight dry-rot on the potatoes planted is thought to promote the early appearance of the foliage blight the next summer, provided the cool, moist weather required for its development occurs. The disease is thus carried to the South Atlantic trucking districts and develops as leaf-blight during the spring, whereas in the North it prevails in late summer.

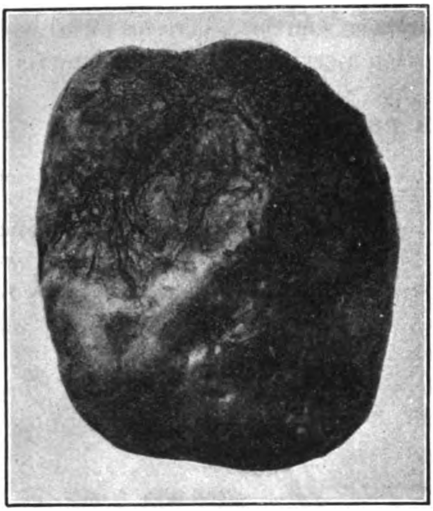

FIG. 11.—A potato affected with dry-rot following late-blight. External view.

Powdery Dry-Rot.

Outside of the regions where the late-blight occurs, storage rot of potatoes is caused principally by three or four species of Fusarium which attack the potato through wounds or follow the wilt fungus. The most serious of these is one most prevalent in the Western States, called the powdery dry-rot (*Fusarium trichothecioides* Wr.), illustrated in figure 13. While this is primarily a wound parasite, it often spreads very rapidly in potatoes in transit to market or stored under unfavorable conditions. It does not attack the growing plant to any extent, but if partly affected potatoes are planted, the fungus lives through the summer and attacks the next crop after it goes into storage. For this reason all potatoes showing any signs of decay should be rejected for planting. The crop should be stored at a low temperature immediately after digging, before any heating can take place. The greatest care should be taken to avoid bruising the potatoes in digging and handling. Storage cellars should be well cleaned and disinfected.

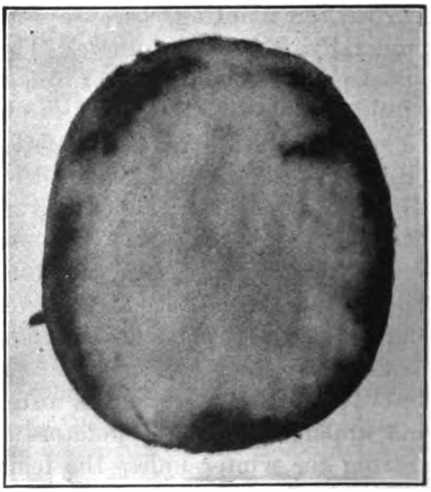

FIG. 12.—A potato affected with late-blight dry-rot. Cross section.

Forms of external dry-rot, caused by other fungi closely related to the foregoing, are not infrequent on injured tubers wherever potatoes are grown. Care in handling and the rejection of partly decayed potatoes for planting are the best preventive measures.

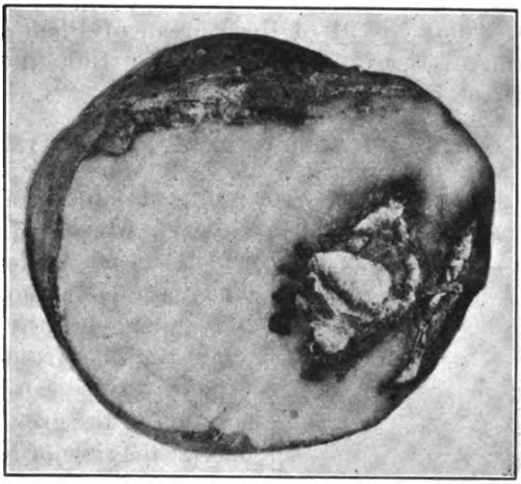

FIG. 13.—A potato affected with powdery dry-rot. Section through a diseased tuber.

OTHER TUBER DISEASES.

Internal Brown-Spot.

When dry, brown spots are scattered through the flesh of the potato and are not restricted to the vascular ring, we have a disease known as internal brown-spot. (Fig. 14.) This is not a parasitic trouble, for the spots consist of dead cells free from bacteria or fungi. Internal brown-spot is associated with dry soils or lack of water at some period during the growth of the tuber and is worse on some varieties than on others. It may indicate that the variety is not adapted to the soil. This disease is not carried in the seed. Its occurrence depends upon soil and climatic conditions. The question has, however, never been settled whether affected seed will produce as large a crop as healthy seed, and many would reject such potatoes on general principles.

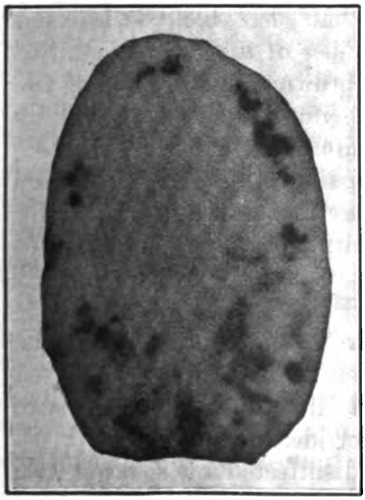

FIG. 14.—A potato affected with internal brown-spot.

Eelworm.

In the Western States and to some extent in the South the eelworm, or root-knot nematode (*Heterodera radicicola.* (Greef) Mül.), must be reckoned with as a factor in potato culture. This trouble is due to a minute worm which attacks the tubers, causing a knotty and irregular appearance. (Fig. 15.) When cut into, such potatoes show a line of glistening spots just beneath the skin. (Fig. 16.) All such potatoes are unfit for planting and constitute a serious danger in that they may carry the pest from one farm to another. Infested soils must be rotated in crops not subject to this pest, as described in Circular No. 91 of the Bureau of Plant Industry. The control of this disease is further treated in Bulletin No. 217 of the Bureau of Plant Industry.

DISEASES NOT APPARENT IN THE TUBERS.

There has lately come into prominence a group of diseases, including leaf-roll and curly-dwarf, which are carried in the tubers but which can not be detected by tuber inspection. These are dangerous troubles, combatable only by securing healthy seed stock from another district. The freedom of a stock from this type of disease can be determined only by inspection of the growing crop, preferably twice, once at the time of blooming and a second time shortly before the harvest.

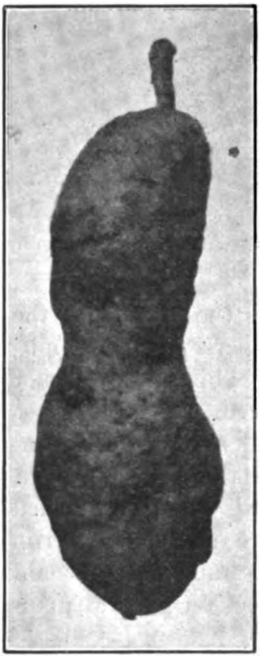

FIG. 15.—A potato affected with eelworms, showing the irregular, knotted appearance of the outside of the tuber.

THE CHOICE OF SEED POTATOES.

Summarizing the suggestions in the preceding discussion it is urged that all seed stock be carefully inspected before purchase or use for planting and that such stock be rejected if any material number of tubers are found to have the stem-end browning, indicative of the wilt diseases or the internal decay caused by the black-leg parasite.

Dry-rot, either of the late-blight or powdery type, unfits potatoes for planting, and badly bruised or wounded potatoes are also likely to give unsatisfactory results.

Eelworm-infested potatoes should never be planted. The only means of restricting the spread of silver scurf is to reject affected potatoes. Any suspected cases of wart disease or powdery scab should be sent to a competent authority for identification.

All potatoes for planting should be disinfected by soaking two hours in a solution of 1 pint of formaldehyde to 30 gallons of water, and after treatment should not be allowed to come in contact with old sacks or barrels that might reinfect them. A formaldehyde-gas treatment, adapted to the disinfection of entire cellars at one time, has been tried, but for the average grower the treatment by soaking is to be preferred.

Finally, the purchaser of seed should insist on being supplied with high-grade stock, to the end that the producer will be forced to control preventable diseases where the seed stock originates.

WHAT FORM OF LEGAL REGULATION OF THE SEED TRADE IS BEST?

With the increased losses from potato diseases and the growing realization of the danger in diseased seed stock there have been several plans suggested for the improvement of conditions through legal enactments involving inspection, treatment, or the prohibition of the shipment of diseased stock. However desirable these may be in theory, their application to actual trade conditions is full of difficulty, and unwise or impracticable restrictions might involve both shipper and purchaser in expense or loss disproportionate to the advantage gained. The vast quantity of potatoes used for planting makes official inspection costly and treatment still more so. The short period of digging in the North compels the greatest haste in all farm operations on account of the imminent danger of freezing weather. It must further be recognized that many of the potato diseases are not familiar to the growers and dealers and might be overlooked in their incipient stages. The most easily detected disease—the scab—does not destroy the value of potatoes for seed if disinfection be practiced.

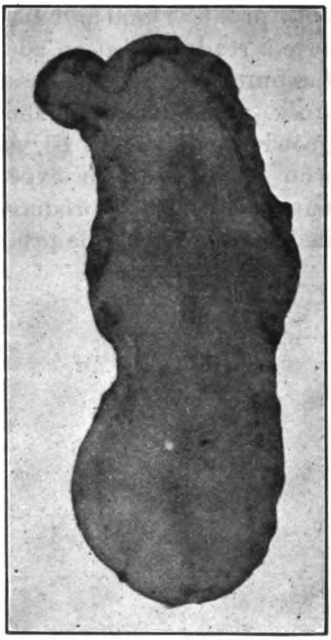

FIG. 16.—Longitudinal section of a potato affected with eelworms.

One form of regulation suggested provides for a State or local quarantine against all potatoes not treated with formaldehyde at the point of origin. This is hardly feasible in commercial practice for the reasons already cited and because black-leg, wilt, and other troubles are not reached by the treatment, while reinfection by the scab might occur in the cars, ships, or warehouses during shipment.

The evidence shows that healthy potatoes can best be secured by growing healthy potatoes, and not by inspecting, fumigating, or quarantining diseased stock. The progressive seed grower can eliminate or control nine-tenths of the diseases described in this bulletin, and will do so if his market requires it and if a premium is paid for the extra labor involved. The method of tuber-unit selection described by Stuart in Farmers' Bulletin 533 will greatly assist in the elimination of many of these diseases from the field. A closer connection between the northern grower and the southern grower would be highly advantageous.

FIELD INSPECTION AND CERTIFICATION.

A plan is suggested whereby the freedom from disease and the varietal purity of seed potatoes may be certified by an officially appointed inspector or committee. This would work to the benefit of both producer and purchaser, for the producer would be able to secure a ready sale at an adequate price for his high-grade crop, while the purchaser would be assured of an opportunity to procure healthy stock. This inspection should be made in the field while the crop is growing. It should be voluntary or at the request of the grower, who should bear the expense. This expense, when divided by the number of bushels produced, would be small and much less than the increased value of the product.

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Issued July 8, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 545.

CONTROLLING CANADA THISTLES.

BY

H. R. COX,
Agriculturist, Office of Farm Management,
Bureau of Plant Industry.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., May 3, 1913.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a paper entitled "Controlling Canada Thistles," by Mr. H. R. Cox, Agriculturist, Office of Farm Management, of this Bureau.

This paper deals with the methods of eradication used for the Canada thistle in the United States, states how it is distributed, and how it may be prevented. It also includes a description of the plant, so that it may be recognized. It should be of considerable assistance to any farmer troubled with Canada thistles.

Respectfully,

Wm. A. Taylor,
Chief of Bureau.

Hon. D. F. Houston,
Secretary of Agriculture.

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B. P. I.—912.

CONTROLLING CANADA THISTLES.

RANGE OF THE CANADA THISTLE.

This weed occurs in the Northern States from Maine to Virginia, west to North Dakota and Kansas, and in the Pacific Coast States from Washington to northern California. It also seems to be spreading in the Rocky Mountain States. But few reports have been received of its presence in the Southern States and it is very probable that this weed will not be a serious pest in that region.

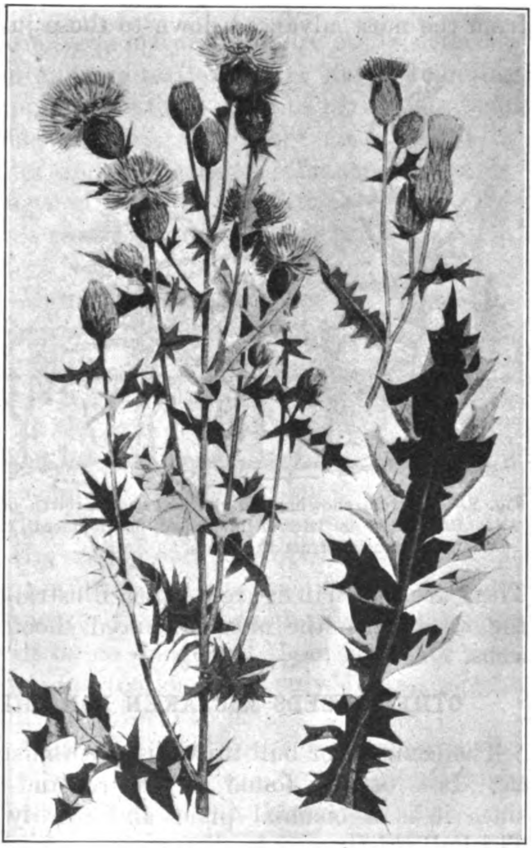

FIG. 1.—Top of the Canada thistle. (Reproduced from "Farm Weeds of Canada," Bulletin of the Department of Agriculture, Dominion of Canada.)

DESCRIPTION OF THE PLANT.

TOPS.

The Canada thistle (*Cirsium arvense* (L.) Scop.) may be identified by its erect, aboveground stems, 1 to 3 feet in height, its lobed and very spiny leaves, somewhat downy on the under side, and its flowers, which are generally rose purple, one-half to seven-eighths inch in diameter, clustered at the ends of the branches. (Fig. 1.)

UNDERGROUND PARTS.

Being a perennial plant, the Canada thistle propagates itself both by its underground parts and its seeds. The character of the underground growth must therefore be understood in order to attack the weed intelligently.

The root, which varies in size from one-quarter of an inch or more down to very small feeding rootlets, branches and spreads in all directions more or less horizontally. The depth of this root varies from a few inches to a few feet below the soil surface, depending on the kind of soil in which it has been formed. From any point along the root buds may form and send up root shoots, which appear above the soil surface as stems or tops of the plant. At any time during the growing season shoots in all stages of development can be found, from the most advanced down to those just starting from the roots. These are shown in figure 2, which illustrates a characteristic patch of the weed when the most advanced shoots have formed their blossoms.

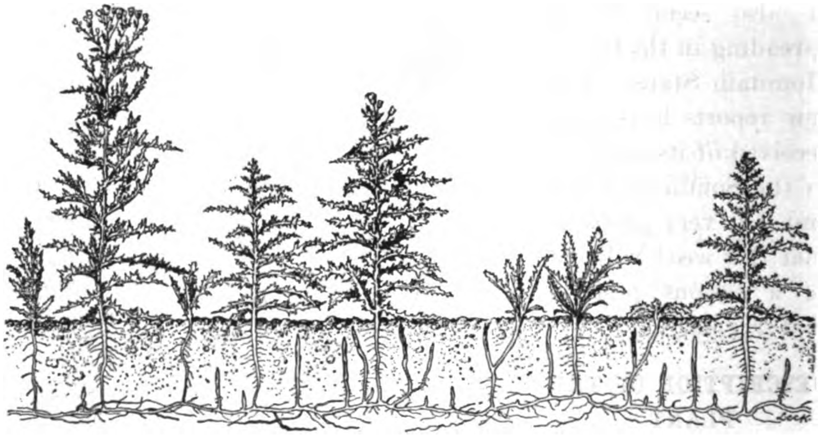

Fig. 2.—Diagram showing the characteristic growth of the Canada thistle. The shoots are illustrated in various stages of development, from the most advanced down to buds just starting from the roots.

OTHER WEEDS MISTAKEN FOR THE CANADA THISTLE.

The common or bull thistle is often mistaken for the Canada thistle. It is usually found in pastures and other uncultivated places, since it is a biennial plant and readily succumbs to cultivation. The bull thistle may be distinguished from the Canada thistle by its greater size, by the rougher and darker green appearance of the leaves, and by its larger heads. Other plants sometimes mistaken for Canada thistles are the bird's-nest thistle in the South Atlantic States, the milk thistle on the Pacific coast, and the curled thistle in the Northern States.

METHODS OF DISTRIBUTION AND MEANS OF PREVENTING IT.

The Canada thistle spreads into new localities, from farm to farm, and even from field to field on the same farm, largely by its seeds. These seeds (fig. 3) are smooth, brown, about one-eighth of an inch long, and nearly cylindrical, being a little pointed at one end. Each seed has a tuft of hairs called a pappus. The time of seeding extends from July to October. This weed is peculiar in that only a few of the plants produce seeds that are able to grow. It is not known just what the conditions are which govern this. In most infested areas enough perfect seeds are formed to greatly increase the nuisance, so that the farmer is not justified in permitting the blossoms to mature. The principal ways in which the seeds are scattered are as follows:

Wind and water.—After the seeds mature they are easily detached from the heads by the wind and are scattered over the surrounding country. The feathered pappus bears them up, thus permitting them to be carried a considerable distance. They are also carried by run-off water down hillsides and by streams. Transportation by water becomes a special danger in irrigated districts, where the ditches and laterals readily carry the seeds over the land.

Small grains and straw.—Mature thistle seeds are often harvested with small grains, but are usually separated from them in thrashing. It is often advisable, however, to reclean such small grain as is to be used for seed, especially in the case of oats. The thistle seeds are carried over into the straw stacks and from them through the manure to the fields; but if such manure is left in piles for several months practically all the seeds will be decomposed. Harvesting machines often carry the seeds to other fields and thrashing outfits carry them from farm to farm.

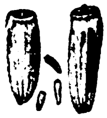

FIG. 3. — Seeds of the Canada thistle, showing, in the center, the actual size of three of them. (Drawn by F. H. Hillman.)

Hay.—If hay is cut sufficiently early, when the thistles are just starting to bloom, there will be no danger of their maturing seed. Many farmers let their hay stand too long, not only diminishing its value but permitting the thistle to form seed.

Grass and clover seed.—Although of infrequent occurrence, the seeds of Canada thistles are sometimes found in grass and clover seed, especially in alsike clover and Canada bluegrass. It is not difficult to detect their presence by the use of a hand lens after a little practice. If in doubt a farmer may send a sample to his State experiment station or to the United States Department of Agriculture, Washington, D. C., for analysis. Farmers' Bulletin 428, entitled "Testing Farm Seeds in the Home and in the Rural School," is of great assistance to farmers in detecting the presence of weed seeds in commercial seed.

METHODS OF KILLING CANADA THISTLES.

After this weed has obtained a foothold the best way to eradicate it is to prevent it from sending up top or aboveground growth, which finally causes the roots to die. This is the basic principle which must be kept in mind at all times. The top of the plant serves much the same purpose as the lungs of animals, so that if the plant is continually deprived of that vital part it must soon die.

There are a number of ways of keeping down the top growth; there is no one best way for all cases. The best method for each case will depend on the farmer's rotation and convenience. Any practicable method will do.

The man, therefore, is of far more importance than the method. Many farmers make a start to kill the thistle, but abandon their efforts too soon. It is probably no exaggeration to say that 95 per cent of the efforts to kill thistles are failures. Often the campaign is abandoned when success is in sight, and the thistles soon recover. One great trouble is that farmers are looking for too easy a method; there is no " primrose path " to thistle eradication. If, however, the farmer understands the basic principle as given above in italic type, decides on a systematic plan, and then faithfully " sees it through to a finish," he will free his farm of the thistle, and this will be accomplished without a great amount of labor or expense.

The following experience with thistles is given in detail because it strikingly illustrates the importance of the man himself in weed control and because the methods used are applicable to nearly every farm.

AN EXPERIENCE IN KILLING THISTLES.

In the winter of 1910–11 Mr. Oscar Montgomery purchased a farm of 76 acres in Fulton County, Ohio. Under negligent farming it had become badly infested with thistles; every field contained patches of the weed. This fact enabled him to buy the place at a comparatively low price.

It was the general opinion in the community that the thistle had come to stay—that it was a dispensation of Providence that could not be altered. The new owner, however, knew the situation and prepared to meet it. On the farm on which he had previously lived he had fought and conquered this pest.

In the spring of 1911 he wrote to the Department of Agriculture for information on the control of the thistle and was supplied with a statement giving the experience of various farmers in killing this weed. With this in mind and supplemented by his own experience he outlined a plan of attack. He knew that the efforts of most farmers to kill this weed were unsystematic and lacked persistence and that the insufficient treatment usually given it, far from reducing its vigor, actually stimulated it to increased growth. All his effort was to be directed toward the prevention of top or above-ground growth, as only a little top growth is usually sufficient to prolong the life of the thistle until the next year.

The various fields were to be devoted to corn, oats, wheat, hay, and pasture. Field A, of which about 3 acres were thickly set to thistles, was planted in corn in check rows, so as to permit thorough cultivation.

Following a suggestion of the Bureau of Plant Industry, he replaced the cultivator shovels with 9-inch sweeps (fig. 4), thus having an instrument which acted as a series of knives run just under the surface. Besides doing as good work in stirring the soil as the shovel or tooth type of cultivator it is much more effective, if the edges are kept sharp, in cutting off the stems of weeds. Mr. Montgomery says that to this implement is due a great deal of the credit of killing out the thistles in his cultivated crops. Some soils are too stony or otherwise unsuitable for this implement. In such cases reliance will have to be put on the ordinary cultivators, and such thistle tops as slip through between the teeth should be cut down with a hoe.

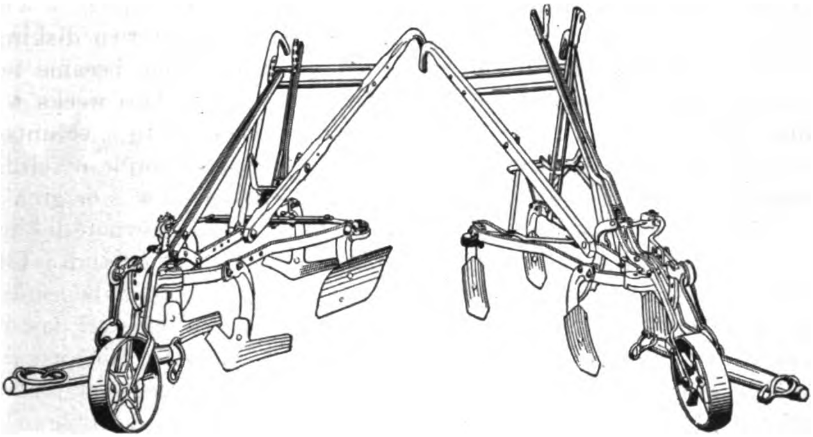

FIG. 4.—A single-row cultivator with shovels (on the right) and the same implement equipped with sweeps (on the left).

Mr. Montgomery could use this tool only until the corn was laid by, however, and since at that time many thistles were still growing he modified his plan of attack, but never lessened its vigor. Having the locations of the thistle patches well in mind he went over them with a hoe, cutting all the tops below the surface of the ground. At the start it was necessary to visit the patches rather frequently (about once a week), but as the season advanced the intervals became less frequent. Assisted by his two children he would attend to it at some odd hour when other work was not pressing. It required about an hour's work each time. He considered it as one of the numerous chores about the place.

After the corn crop was taken off this field was plowed. In the spring of 1912 it was again planted in corn for the purpose of locating and killing any stray plants that might have persisted, but somewhat to his surprise not a thistle top appeared in the field. The weed had been killed in one season with a little extra work.

Field B was left in pasture during 1911. (Fig. 5.) On the advice of the Department of Agriculture about 2 acres of this field that were most thickly infested, together with a small infested area in an adjoining meadow, were plowed in June just before the thistle blossomed. After that, this plowed area was gone over frequently with a disk and no tops were permitted to appear. About two diskings a week were required at the start, but gradually they became less frequent, until toward the close of the season one in two weeks was sufficient. In 1912 this area was allowed to come up to a volunteer growth and not a thistle top appeared—a second example of eliminating the weed entirely in one year. Since this area was originally so full of thistles as to be practically worthless, the owner did not consider that the fallowing cost him the use of the land. This fallowing is best done in the latter part of the season, beginning about the time thistles start to blossom. It may be done on pasture land or may immediately follow hay or grain harvest. It is usually best to follow this treatment with a cultivated crop the next year to kill any of the weeds that may persist.

The rest of field B was pastured throughout the season. In the latter part of June Mr. Montgomery started to cut the thistle tops in the several scattered patches. He cut below the surface of the soil with a sharp hoe frequently enough to prevent most of them from appearing. Here, as on the fallowed area, the intervals lengthened with the waning vitality of the plant. In 1912 this part of field B was plowed and put to corn and a thorough search by this owner and the writer in September failed to disclose a single plant. Here, too, the weed had been eradicated.

Field C was in oats in 1911. Every farmer who has harvested oats with thistles in them knows the inconvenience he suffered, as well as the liability he incurred of spreading the seed to other parts of the farm. No thistles went to seed in this case. One day before they started to blossom Mr. Montgomery cut the most thickly infested patches, oats and all. Where the thistles were less numerous he cut down each of the tops with a sharp hoe. The result was that the crop of oats was entirely free from thistles. Early in the spring of 1912 this field was seeded to grass and clover, the wheat seeding having failed owing to the severe winter. The same procedure was followed in this case as with the oats and a clean crop of hay resulted. Mr. Montgomery did not expect that this treatment would kill the thistle. His object was to produce clean crops, prevent the thistle from seeding, and weaken its vitality as much as possible. He expects this treatment to hold it in check until the field is planted to a cultivated crop.

Mr. Montgomery did not seem to regard his work with the thistle as especially burdensome. Although considerable labor was required the first year, it was scarcely to be considered when compared to the results secured. The first year's campaign was so successful that the work required in 1912 did not amount to more than two days for one man. The principal point in the eradication of thistles, and one that is difficult for many farmers to appreciate, is that this work was kept in mind at all times and attended to faithfully. Once begun it was continued persistently until the thistle tops ceased to appear.

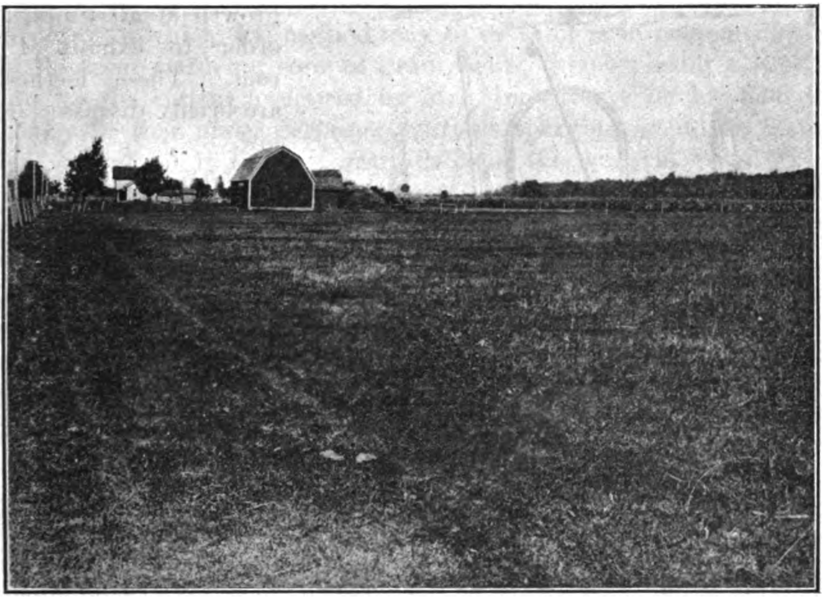

FIG. 5.—A view of the Montgomery farm (with the pasture, field B, in the foreground) on which the thistle was eradicated in one season.

Meanwhile the neighbors had been taking notice. Many of them on visiting the farm evinced surprise at seeing no thistles. Some of them have grasped the idea and have adopted similar methods. Several started the fallow treatment in the summer of 1912. Others have purchased sweeps for their cultivators and are hand-hoeing the thistles after laying by.

OTHER METHODS.

Various types of cultivators equipped with knives or sweeps that are effective in cutting off the tops of Canada thistles are shown in figure 6.

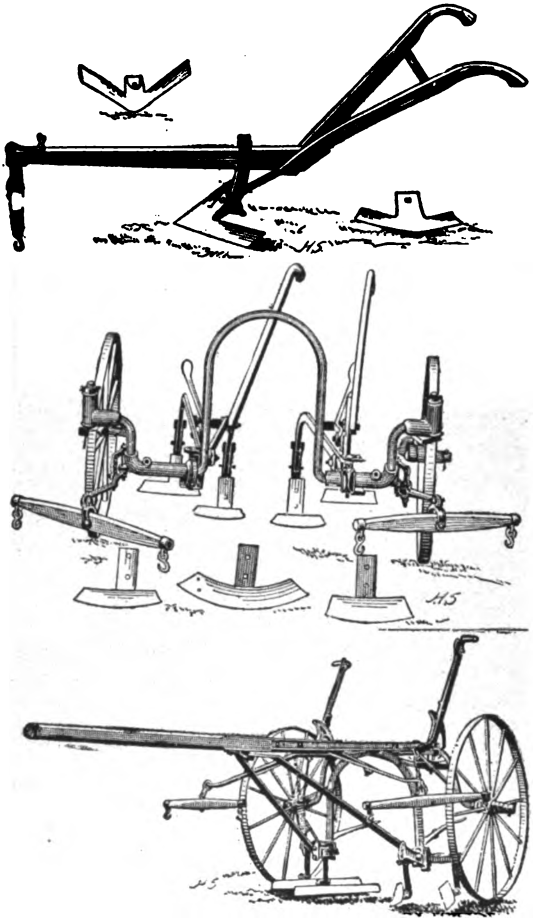

Fig. 6.—Various types of cultivators equipped with knives or sweeps that are effective in cutting off the tops of Canada thistles.

Although the cultivation methods here described will have to be relied on largely in killing Canada thistles, there are other methods that may be followed with considerable success. In using any of them the farmer should never lose sight of the all-important point of keeping down the top growth at all times, in order to exhaust the root. These methods are briefly discussed below.

Growing smother crops.—Among the crops adapted to the purpose of smothering Canada thistles are alfalfa, clover, the grasses, millet, sorghum, hemp, buckwheat, and small grains. Their effect is not only to restrict the top growth of the thistles by shading them, but also to crowd the roots. The land should be occupied by such crops at all times, so that the thistle has no chance to make a recovery. This method seems to be the best adapted to the deeper and more productive soils, where such crops grow well and where the thistle is apt to persist for a longer period than on the shallower and less productive soils. Alfalfa is probably best for this purpose. Good grass and clover stands have also been known to rid fields of thistles.

This method is not as sure in its results as clean cultivation, and seems to be of most value in giving the weed a setback more or less severe, which renders easier the work of clean cultivation that should follow.

Salting thistles in pastures.—The method of salting thistles in pastures is adapted to small patches accessible to live stock, especially sheep. In their effort to get the salt the stock nibble the thistles and trample them to death. It seems best to let them grow until they start to bloom and then cut off the tops close to the ground and apply a small handful of salt to each new shoot that springs up.

Spraying with chemicals.—Experiments for the purpose of permanently eradicating this weed by the application of plant poisons have not proved very practicable. This is a new subject, however, and further investigations are needed before definite advice can be given. Although the tops may be injured more or less, the plants make a renewal growth at once. Hence, it appears at present that about the only way in which this method may be of value is in preventing the thistle from maturing seed in grain fields, thereby being a substitute for the cutting practiced by Mr. Montgomery on his field C. It may be that under certain conditions spraying would be better than cutting, as in the vast grain fields of the semiarid West. The best materials for this purpose seem to be solutions of common salt, iron sulphate, and arsenite of soda, which is poisonous to man and live stock.

Methods on waste lands.—The Canada thistle commonly occurs along roadsides and fences, in woodlands, and on other uncultivated lands, where it matures seed, thus being a menace to the surrounding country. In many cases about all that can be done is to prevent seed from maturing by cutting off the tops at or below the soil surface just as blossoming starts. It will usually be necessary to make two cuttings a year to prevent seeding. Thistles in such locations can be entirely eradicated, however, by continually cutting off the tops until the roots are exhausted.

SUMMARY.

Canada thistles can be eradicated in a comparatively short time with little or no loss in the use of the land. The length of time required varies inversely with the thoroughness of the work.

In dealing with this weed the following three rules must never be lost sight of:

(1) The easiest way of killing Canada thistles is to deprive them of their tops continually, thus exhausting the roots. There are various methods of keeping down the tops; there is no one best method. Each field presents a problem in itself and must be handled according to circumstances. Usually some form of clean cultivation is the best, either with a crop or by bare fallow.

(2) Outline a systematic plan of attack.

(3) Keep the plan in mind at all times and follow it faithfully.

STATE LAWS RELATING TO CANADA THISTLES.

The following statement has been furnished by the Solicitor of the United States Department of Agriculture:

> In none of the States does the law direct that the Canada thistle be entirely destroyed. In all the following States it is proscribed as a noxious weed, and the law directs its killing or destruction in such a manner as to prevent the maturing and dissemination of seed:

California.
Connecticut.
Delaware.
Idaho.
Illinois.
Indiana.
Iowa.
Kansas.
Kentucky.
Michigan.
Minnesota.
Missouri.
Montana.
Nebraska.
New Jersey.
New York.
North Dakota.
Ohio.
Oregon.
Pennsylvania.
South Dakota.
Utah.
Vermont.
Washington.
Wisconsin.

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Issued June 26, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 546.

HOW TO MANAGE A CORN CROP IN KENTUCKY AND WEST VIRGINIA.

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BY

J. H. ARNOLD,
Agriculturist, Office of Farm Management.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., May 14, 1913.

Sir: I have the honor to transmit and to recommend for publication as a Farmers' Bulletin the accompanying manuscript, entitled "How to Manage a Corn Crop in Kentucky and West Virginia," by Mr. J. H. Arnold, Agriculturist, Office of Farm Management.

Respectfully,

Wm. A. Taylor,
Chief of Bureau.

Hon. D. F. Houston,
Secretary of Agriculture.

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HOW TO MANAGE A CORN CROP IN KENTUCKY AND WEST VIRGINIA.

SELECTION OF LAND.

Land which has been in grass and clover sod for a year or two is best for corn. Such land would be increased in fertility by manure or by any kind of vegetable matter plowed into the soil. The land should be well drained; otherwise the corn produced will not pay for the labor put upon it. Any well-drained land with a fair quantity of vegetable matter in it can be made to produce a paying crop by proper fertilization and cultivation. The manure may be applied to the land before plowing. It will do the land good to put it on at any time, even as a top dressing.

PREPARATION OF SEED BED.

Land that has been well sodded, having plenty of grass roots in it, may best be plowed in the fall or winter. The freezing of the soil pulverizes it and puts it in good condition for the planting of seed and for holding the moisture. Some soils, because of texture and lack of vegetable matter, pack during the winter, and for that reason it may not be economical to plow in fall or winter. Plow about 6 inches deep, and deeper if not too much "dead" clay would be turned to the surface thereby. In some cases it may benefit the seed bed to run a bull-tongue or subsoil plow behind the turning plow. This breaks up the subsoil and gives better drainage without bringing lifeless clay to the surface.

Immediately after plowing, the land should be harrowed, in order to break up clods and make the surface smooth, so as to hold moisture better. This is particularly important if the land has been plowed in the spring. Before planting, harrow and disk the land as often as time will permit. These operations conserve moisture, kill growing weeds, and put life into the soil. It pays, even though corn planting may be delayed thereby. In high altitudes and the more northern latitude of West Virginia it is dangerous to delay corn planting later than May 20.

FERTILIZER.

Well-rotted stable manure is the best fertilizer that can be used for corn, but any kind will do the land good. When enough is not available to spread over an entire field, recourse may be had to commercial fertilizer. Commercial fertilizer should always be broadcasted. This is done so that the roots which fill all parts of the upper 3 or 4 inches of soil may get the food from the fertilizer. The best results are usually obtained by broadcasting the phosphate and potash before planting, and then thoroughly working it into the soil. These may be bought separately by the farmer and mixed. The proportion in the mixture should be 250 to 300 pounds of acid phosphate (14 to 16 per cent) to 50 pounds of muriate of potash. In many sections of Kentucky potash is not recommended or needed. When the roots of the corn are well distributed in all parts of the soil, or about the time the corn begins to tassel, the crop, if it is not vigorous, may be economically benefited by the application of nitrate of soda. This should be scattered between the rows at the rate of 75 to 100 pounds to the acre.

SEED.

Get as good seed corn as can be had in the community and a variety that is standard and thoroughly tested for the locality. It is not advised to plant such late-maturing varieties as Boone County White and Johnson County White north of Parkersburg and on altitudes above 1,500 feet in West Virginia. In the northern part of West Virginia such varieties as Reed's Yellow Dent mature very well. On top of the Allegheny Mountains in West Virginia, 2,000 to 4,000 feet in altitude, none but the earliest maturing varieties will mature, even when planted early. Test the seed before planting.

PLANTING.

On good soils that hold moisture fairly well and have plenty of plant food, plant 3 feet 6 inches each way, or drill 10 to 18 inches in the row and 3 feet 6 inches apart, putting two or three grains in the hill, depending on the fertility and water-holding power of the soil. Plant not over 3 inches deep. A uniform stand may be obtained by planting four to five grains of tested corn in the hill and thinning to two or three stalks in the hill, according to the fertility of the soil. Plant as soon as the seed bed is in good condition and the weather permits. In the high parts of West Virginia planting should not be delayed too long.

CULTIVATION.

On smooth, loose ground without stones it does not injure corn to harrow the ground any time after planting until the corn is 2 to 4 inches high. It is best to slant the teeth of the harrow. Harrowing cleans the ground and conserves moisture. Cultivate every week or 10 days when possible. Use a small-tooth cultivator and cultivate shallow. The principal aim in cultivating should be to keep down weeds, whose growth takes from the soil moisture and food which the corn needs. Under average conditions, deep cultivation which disturbs the roots of the corn is positively injurious and may ruin the crop.

HARVESTING.

The corn crop may be best utilized by cutting the corn and shocking it when the grain has hardened but before the stalks are dead and before frost. Each shock should contain the corn in 16 hills square. A profitable way to utilize a crop where a large number of stock is kept is to haul the shocked corn to the barns and shred it. It may also be husked in the field and the cattle turned in to eat the fodder. One of the best ways of utilizing the corn crop is to silo it. Corn should be put in the silo at the same time it would be ready to cut and put into the shock. In many places in western Kentucky it would be profitable to own a corn-harvesting machine which would cut and bind the corn to be shocked or siloed. It would not pay to own such a machine unless there was a large enough acreage—40 to 100 acres.

SOURCES OF INFORMATION REGARDING CORN GROWING.

For specific information in regard to corn growing in a locality the farmer should consult experts in the State agricultural experiment station. A card or letter addressed to the State experiment station at Lexington, Ky., or Morgantown, W. Va., will receive attention. Information and assistance may also be had through the State commissioner of agriculture at Frankfort, Ky., or Charleston, W. Va. Farmers' Bulletins 81, 229, 253, 313, 400, 414, and 415 of the United States Department of Agriculture relate to corn growing. Farmers' Bulletin 537, entitled "How to Grow an Acre of Corn," by Mr. C. P. Hartley, in charge of the corn investigations of the United States Department of Agriculture, contains information of special value to corn growers. These publications will be sent without cost to any person making application therefor to a Senator or Representative in Congress or to the Secretary of Agriculture, Washington, D. C.

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Issued July 26, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 547.

THE YELLOW-FEVER MOSQUITO.

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BY

L. O. HOWARD, M. D., Ph. D.,
Chief of the Bureau of Entomology.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Entomology,
Washington, D. C., May 1, 1913.

Sir: I have the honor to transmit for publication a paper dealing with the yellow-fever mosquito. It is intended to be a companion to Farmers' Bulletins 444 (Remedies and Preventives against Mosquitoes) and 450 (Some Facts about Malaria), and should therefore be published in the same series. This manuscript has been adapted from a Monograph of the Mosquitoes of North and Central America and the West Indies, by L. O. Howard, Harrison G. Dyar, and Frederick Knab, published by the Carnegie Institution of Washington.

Respectfully,

L. O. Howard,
Entomologist and Chief of Bureau.

Hon. D. F. Houston,
Secretary of Agriculture.

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THE YELLOW-FEVER MOSQUITO.

(*Aedes calopus* Meig.)

HOW TO RECOGNIZE THE YELLOW-FEVER MOSQUITO.

The only species of mosquito which has been shown to transmit yellow fever is a small form well known in the Tropics. It is somewhat variable in size, but on the whole is so small as to require a mosquito bar of 20 strands, or 19 meshes, to the inch to prevent its entrance to screened rooms. Both males and females can pass through a netting containing 16 strands, or 15 meshes, to the inch. It is a strikingly marked, and, on the whole, when seen under the lens, a beautiful insect. Its general color is dark, but its thorax is marked with a silvery white, lyre-shaped pattern; the abdomen is banded with silvery white, and there is a silvery white spot on each side of the abdominal segments. The legs are banded alternately with black and pure white, and the long palpi of the male are also alternately banded with black and pure white. As with many other species of mosquito, the antennæ of the male

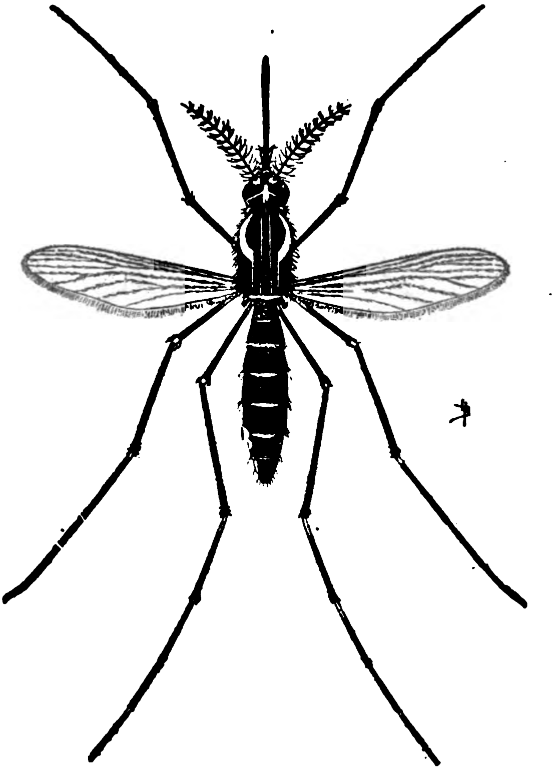

FIG. 1.—The yellow-fever mosquito (*Aedes calopus*): Adult female. Much enlarged. (Original.).

are broadly feathered, while those of the female are only slightly feathered. The accompanying illustrations (figs. 1–3) well indicate the general appearance of the insect.

DIFFERENT NAMES BY WHICH IT HAS BEEN CALLED.

Popularly the yellow-fever mosquito has been called in the Tropics the house mosquito, the day mosquito, the banded-legged mosquito, and is now generally known as the yellow-fever mosquito. Sometimes also it is known popularly by one of its discarded scientific names, the Stegomyia mosquito.

Scientifically this species was first known as *Culex fasciatus* Fabr. After the publication of Theobald's Monograph of the Mosquitoes of the World it was known as *Stegomyia fasciata* Fabr. Later, after Blanchard pointed out that the name *fasciata* was preoccupied in the same group, it was known as *Stegomyia calopus*. Recent investigations have shown that Stegomyia is not a valid genus, and the insect is now known as *Aedes calopus* Meig.

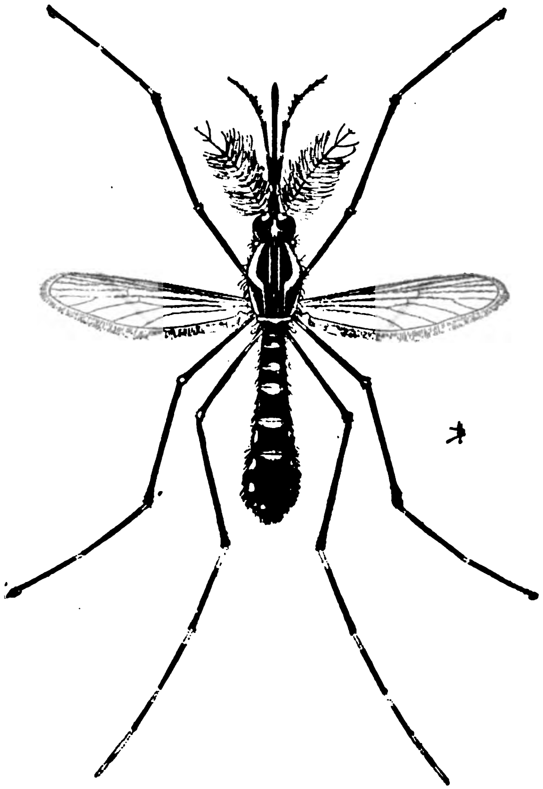

FIG. 2.—The yellow-fever mosquito: Adult male. Much enlarged. (Original.)

DOMESTICITY OF THE SPECIES.

The yellow-fever mosquito is inseparably associated with man in the Tropics. It is essentially a town mosquito, and normally it is never found at a great distance from habitations. It shows a very decided preference for human blood, and it must have blood for the development of its eggs. Both sexes inhabit houses, and when there is a supply of water the entire life cycle takes place indoors. Its long association with man is shown by many of its habits. It approaches stealthily from behind. It retreats upon the slightest alarm. The ankles and, when one is sitting at a table or desk, the underside of the hands and wrists are favorite points of attack. It attacks silently, whereas other mosquitoes have a piping or humming note. The warning sound has doubtless been suppressed in the evolutionary process of its adaptation to man. It is extremely wary. It hides wherever it can, concealing itself in garments, working into the pockets and under the lapels of coats, and crawling up under the clothes to bite the legs. In houses it will hide in dark corners, under picture moldings, and behind the heads of old-fashioned bedsteads. It will enter closets and hide in the folds of garments.

HABITS OF THE ADULT.

FEEDING HABITS.

The female sucks blood when it is available, and needs blood to develop her eggs. In captivity she has been kept alive for a long time on honey or other sweet substance. She is attracted to portions of the body covered with perspiration. A female will bite within 18 to 24 hours after she emerges from the pupa. Virgin females will bite, but fertilized females are more greedy. After a meal of blood she is very sluggish; she flies with difficulty, seeking a hiding place for digestion. Several hours are consumed in digestion, and then the female is anxious for another meal of blood. The species normally sucks blood repeatedly. In 31 days a female is recorded to have sucked blood 12 times. By biting a number of different individuals the chances of becoming herself infected with yellow fever and transmitting the disease are greatly increased.

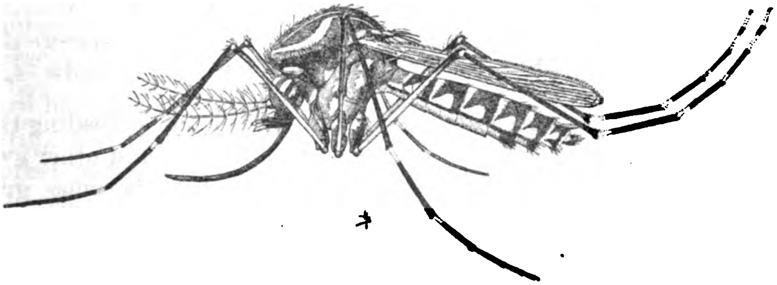

FIG. 3.—The yellow-fever mosquito: Adult female, side view. Much enlarged. (Original.)

The yellow-fever mosquito can subsist upon the blood of any warm-blooded animal, but shows a decided preference for man. It prefers the white race to dark races, and among the whites attacks by preference young, vigorous persons of fine skin and good color rather than anemic or aged people. It will also feed upon birds, and it has been carried alive from Brazil to Europe by being fed upon canary birds. Instances are on record of the biting of corpses.

TIME OF ACTIVITY.

The popular name in the British West Indies, "day mosquito," is derived from the fact that this species is usually active and bites only in the daytime, although, where there is a light in the room, it may also bite at night. It is especially voracious early in the morning about sunrise and again late in the afternoon. It does not bite in the bright sunlight out of doors, and in fact is not in evidence in the open. On cloudy days it bites at all times. Antimosquito lotions for the skin, used in unscreened houses at night, are not so apt to be effective against this species as against other semidomesticated species, such as *Culex quinquefasciatus* and the species of Anopheles, for the reason that at the time when the individual is soundest asleep, in the early morning hours, the lotion will largely have evaporated, and the yellow-fever mosquito begins to bite only when the sunlight first enters the room.

LENGTH OF LIFE OF ADULTS.

Adult females have been kept alive for long periods by feeding them upon bananas and other fruit, upon honey, molasses, and other sweet substances. Beyond the fortieth day the mortality becomes great. They will live longer where the atmosphere is moist. Guiteras, in Cuba, kept five infected adults alive for 101 days and one for 154 days. The oldest male that has been kept in captivity lived for 72 days. The question of how long infected yellow-fever mosquitoes may be capable of conveying the disease has received some attention. Having acquired the infection from a yellow-fever sufferer they are dangerous after the twelfth day, and probably continue dangerous as long as they are capable of biting.

INFLUENCE OF TEMPERATURE.

The cessation of former yellow-fever epidemics in the southern United States on the appearance of the first cold weather in November and December was due to the fact that the yellow-fever mosquito is killed by cold. It is, in fact, extremely sensitive to differences in temperature. It displays the greatest activity when the thermometer is in the neighborhood of 82° F. As the temperature rises or falls a few degrees above or below that point there is a markedly reduced activity. Beyond 102° F. heat is fatal. When the thermometer falls below 62° the mosquito becomes sluggish and will not feed. At from

54° to 57° F. it becomes torpid, flies with difficulty, and no longer stands firmly on its legs. It dies quickly when the temperature is at the freezing point. When exposed for a brief period to a temperature of 49° and then placed in a warm room it will revive, but it dies at a temperature of 39° maintained for more than an hour. It may be kept alive for some time at temperatures of 45° to 48°.

DISTANCE OF FLIGHT.

The yellow-fever mosquito is a strong flier; nevertheless, it does not fly very far and, as has been already pointed out, is rarely found away from houses. It apparently never flies very high and is found by preference in the lower stories of houses. There is conflicting evidence regarding the effect of a strong current of wind on this species, and it is recorded that strong air currents produced by a mechanical ventilator had no effect upon flight. Other observers have searched for it in vain in situations exposed to the wind.

The distance of flight has an important bearing upon the distance at which ships should be anchored from fever-infected ports, but with vessels anchored at given distances it is most difficult to determine whether yellow-fever mosquitoes which may be found on board have flown from the shore or have been carried by boat parties visiting the vessel, perhaps concealed under coat collars or hidden in other parts of clothing. There is no positive evidence that vessels anchored more than half a mile from the shore will be visited by the yellow-fever mosquito by natural flight.

DISTRIBUTION BY ARTIFICIAL MEANS.

Although, as indicated in the preceding section, the yellow-fever mosquito apparently does not fly far, it is readily carried to great distances accidentally by artificial means. Vessels, once infested, may carry the species to far-distant ports. The yellow-fever mosquito has been found in New York upon vessels coming from Vera Cruz, and it is by such carriage of infected mosquitoes that the early outbreaks of yellow fever in Philadelphia and other northern cities are to be accounted for.

Railway trains also carry this mosquito, frequently in large numbers. It has spread inland from Vera Cruz, first to Cordoba and later to Orizaba, entirely by means of the railway. Almost every summer the yellow-fever mosquito is carried in railroad cars from New Orleans, Mobile, and other southern cities, on through trains, to Washington, Baltimore, and New York. It has been seen and captured on these trains by competent entomologists.

MATING.

The mating of the species usually occurs during flight, although the female sometimes alights during the act and before its completion. The act requires but a fraction of a minute. Temperature has a great influence upon sexual activity. Below 68° F. mating seldom occurs. The same male may have frequent connections in rapid succession with various females.

RELATION OF FOOD TO EGG LAYING.

It seems certain that the female can not develop her eggs without having had a meal of blood. After a meal eggs will be deposited in a few days. If a fertilized female is fed upon sweet substances, the eggs will not develop. If afterwards, say after 15 or 20 days, she is fed blood, the eggs will then develop. Blood food, however, in hastening the development of the eggs shortens the life of the mosquito. A diet of honey, on the other hand, prevents the development of the eggs and prolongs life. The shortest interval between a blood meal and egg laying is apparently two days, and the longest seven days.

BREEDING HABITS.

EGG LAYING.

The eggs are laid separately in several lots, the individual lots being laid at intervals of several days or more. They may be laid near the water, close to its edge, or upon the surface of the water. Oviposition on the surface of the water, however, is probably rare, and possibly occurs only under abnormal conditions, when the mosquitoes are being studied in captivity. Normally it appears to be the custom to lay them on the sides of a receptacle containing water, just above the surface of the water, so that a slight elevation of the water will submerge them. They have been found upon a leaf floating upon the water.

Sometimes the female will lay but one lot of eggs. Others will lay two lots, and others from three to seven. According to J. R. Taylor, the total number of eggs laid at a time varies from 35 to 114. Other observers have increased the number to 150. Undersized females rarely lay more than 50 eggs. The death of the female after egg laying seems to indicate that all the eggs have been laid.

THE EGGS.

The eggs are small and black in color and are well shown in figure 4. As has been stated, they are ordinarily laid above the margin of the water, and here they may remain dry for long periods, hatching when reached by the water. They develop better after having been dry for some time. In fact, it seems that they will preserve their vitality dry for six months or even longer. Freezing does not destroy the fertility of the eggs. The duration of the egg stage, when the eggs are laid upon the water, is about two days; when deposited above the water they hatch promptly when submerged. When laid upon the surface of the water they are easily sunk by any disturbance, and when they sink hatching is retarded and often some of the eggs do not hatch, particularly if the temperature of the water is rather low. When submerged soon after being laid on the surface of the water they generally perish.

BREEDING PLACES.

The probabilities are that the yellow-fever mosquito originally bred in water in holes in trees, but it has so perfectly adapted itself to the human species that it has become a true domestic insect and is practically dependent for its existence upon the conditions that surround human habitations. This adaptation is undoubtedly of very ancient development. The yellow-fever mosquito is essentially a town mosquito, and the larvæ are found practically exclusively in artificial receptacles in and about houses. It can be said that its larvæ are never found in swamps, in pools, or even in temporary puddles, even when these are in close proximity to houses. In the Tropics the large earthen jars in which drinking water is kept are the most frequent and unfailing habitat of the larvæ. Rain-water barrels are abundant breeding places. Rain-water tanks, so universally behind the houses in southern cities like New Orleans, Galveston, and Mobile, are the source of most abundant supplies of these mosquitoes. The larvæ are also found in sagging gutters containing rain water, in tin cans, in cesspools, in horse troughs, in water-closet tanks, in the drain traps of stationary washstands, in the urns in cemeteries, in the holy-water fonts in churches, in pools accumulating under the water tanks, in water pans in the chicken yards, and in the water receptacles of grindstones.

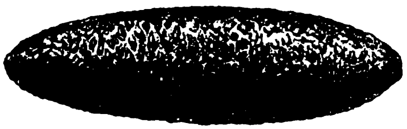

FIG. 4.—The yellow-fever mosquito: Egg. Greatly enlarged. (Original.)

The observations of Busck and Knab in the West Indies and Central America indicate that the yellow-fever mosquito breeds almost always in clear water and seldom in foul water. These observers always found it in artificial receptacles, except a few times in tree holes near houses, and in one case in a street gutter. In the last case it is probable that this larva came into the gutter by the emptying of some household vessel. Discarded bottles and tins about houses are favorite breeding places. The larvæ occur in tree holes only when the latter are in close proximity to human habitations.

BEHAVIOR OF LARVÆ.

The larvæ (fig. 5), when suspended from the surface film of the water to take in air, hang almost perpendicularly. They are very easily alarmed and then go quickly to the bottom, where they remain a considerable time. They can live under water for a long time without rising to the surface. When water is poured from a receptacle inhabited by these larvæ they quickly seek the bottom, and their presence may not be suspected, although the vessel is in constant use. They cling so closely to the bottom that unless the jars are rinsed and tipped up so as to empty them completely, which is not usually done, nearly all the larvæ will remain in the jars. On account of this habit they are not easily disposed of by pouring out the contents of a barrel.

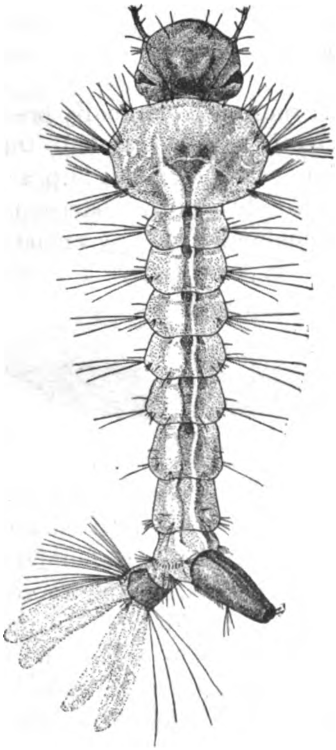

FIG. 5.—The yellow-fever mosquito: Larva. Much enlarged. (Original.)

FOOD HABITS OF LARVÆ.

The larvæ occur most frequently in clear water in rain-water barrels or in drinking-water receptacles in houses. The water in such receptacles contains more or less animal matter as well as vegetable refuse, and such probably is generally the food of the larvæ. The larvæ feed at the bottom, where they mouth over the organic sediment, even when the water is very deep. Larvæ in confinement may be observed chewing vigorously on dead insects or larval or pupal cast skins. They are sometimes cannibalistic, the larger larvæ devouring the smaller ones.

The growth of yellow-fever mosquito larvæ is hastened by the presence of a small amount of fecal matter in the water. Observers in Habana at the time of the Cuban war found that the larvæ which bred in the tin cans used for carrying away human excrement from the hospitals developed rapidly, and other observers have recorded the fact that by adding fecal matter to the water in which were larvæ under observation the development was hastened until the life cycle was completed in from six to eight days.

DURATION OF EARLY STAGES.

Temperature has the greatest influence, not only upon the hatching of the eggs but also upon the subsequent development of the larvæ. The effects of various temperatures on the early stages were carefully investigated by the American commission in Cuba and by the French commission in Rio de Janeiro, and the results of both agree very closely. The shortest period of development to imago observed by Reed and Carroll during summer weather in Cuba was 9½ days, divided as follows: Incubation, 2 days; larval stage, 6 days; pupal stage (fig. 6), 36 hours. This, however, was believed to be exceptional. In average summer temperature the time required for the complete metamorphosis ranges ordinarily from 11 to 18 days. The French observers in Rio de Janeiro found that the most favorable season for rapid development was when the night temperatures ran from 79° to 81° F. and the day temperatures from 82° to 88° F. They found that some of the larvæ of this mosquito reached the pupal stage seven days after the hatching of the eggs, and the adult condition on the ninth day, and that generally most of the larvæ from the same laying of eggs produced imagoes about the tenth day.

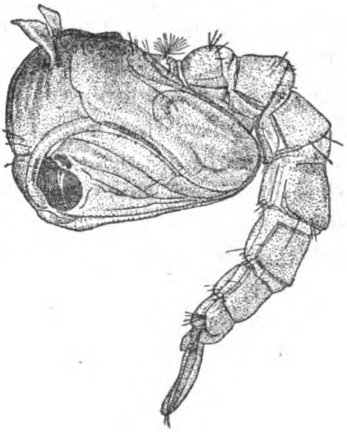

FIG. 6.—The yellow-fever mosquito: Pupa. Much enlarged. (Original.)

RESISTANCE OF LARVÆ TO ADVERSE CONDITIONS.

Larvæ of the yellow-fever mosquito have been found in nature in brackish water containing 35 per cent of sea water. With 40 per cent sea water the larvæ still survived and produced imagoes. Experiments have shown that the larvæ may in nature survive in water which, through evaporation, has reached a high degree of salinity, and if afterwards, through rains, the water becomes again diluted, the larvæ may develop to imagoes.

The degree of resistance to desiccation of both larvæ and pupæ is important from the practical standpoint. The first yellow-fever commission to Vera Cruz found that in that dry climate larvæ died quickly when the water containing them was poured on the ground. In moist climates the larvæ may, under favorable circumstances, live out of water a considerable time, and the pupæ show great resistance to drying. Experiments made by Peryassu in Brazil showed that when larvæ were placed upon filter paper none lived nine hours. When placed upon moist ground, according to temperature and evaporation, they survived as much as 13 days, and when again put in water developed to imagoes. Pupæ dried upon filter paper survived up to 9 hours and 30 minutes.

GEOGRAPHIC DISTRIBUTION.

In considering the geographic distribution of the yellow-fever mosquito it should be pointed out at the start that it has two distinct regions—one in which it is capable of breeding continuously and another over which it spreads during warm weather, to be annually exterminated by cold after breeding for an indefinite number of generations. The first may be termed the permanent region and the second the temporary summer region. The permanent distribution is limited in a general way by the frost line. Where frost does not occur the species generally may breed permanently. As has been already shown, this mosquito does not thrive below a temperature of 80° F., so that in a uniform climate with a temperature much below 80° the species will not continue to exist. Such climates are rare, however, in regions where frost never occurs.

The temporary summer distribution is determined by the means of carriage that happen to be available. It has been shown that the yellow-fever mosquito is a domestic species, having a fairly long life in the adult stage and having the custom of hiding itself in the most ingenious ways. It is therefore particularly subject to carriage for long distances on board vessels, in railway trains, and even packed securely away in baggage. In the old days of sailing vessels on very long voyages it was not only possible for the yellow-fever mosquito to breed continuously in the more or less exposed water supply of vessels, but undoubtedly this was of common occurrence. Every year it is carried to the north in the United States upon railway trains and may breed for a generation or so hundreds of miles north of its permanent breeding places. Thus while the species breeds permanently only in the extreme southern portion of the United States, it will be found every summer breeding for a generation or so in localities to which it has been carried by trains. In 1904, for example, it was found breeding abundantly upon the grounds of the St. Louis exposition, and had one or more persons suffering with incipient yellow fever come to the exposition, the mosquitoes were there in numbers to carry the disease. Everywhere almost throughout the southern United States in midsummer will this mosquito be found, and this explains why epidemics of yellow fever have occurred in years past on the Atlantic coast of North America even as far north as Montreal.

On the Pacific coast, on the other hand, the nights are so cold that this species does not seem to be able to survive. This applies to points north of San Diego. The species breeds permanently in all of the west coast Mexican seaports, and must frequently be brought to the California coast in vessels, but it has never been known to breed there. This seems at first sight strange, since the mean annual temperature of California is much above that of eastern cities where epidemics have occurred, and in San Diego and Los Angeles one sees tropical vegetation on every hand growing unprotected, and severe cold is unknown; yet the nights are cold even in the summer, and it is to this condition—the low minimum nightly temperatures—that freedom from the yellow-fever mosquito, and consequently from yellow-fever epidemics, is due.

ORIGINAL HOME.

The original home of the yellow-fever mosquito must clearly be identical with that of yellow fever. Early history points very strongly to the West Indies and the adjacent mainland as that original home. There has been much discussion of the question, and ingenious arguments have been adduced to prove that yellow fever is of African origin and was imported into America through the slave trade. All things considered, however, the probabilities are that yellow fever is one of the very old diseases of mankind in the New World, and that it was taken from the New World to the Old.

DISCOVERY OF THE RELATIONS OF THIS MOSQUITO TO YELLOW FEVER.

Physicians had been theorizing about the cause of yellow fever from the time when they began to treat it. It was thought by many that it was carried in the air, by others that it was conveyed by the clothing, bedding, or other articles which had come in contact with yellow-fever patients. There were one or two early suggestions of the agency of mosquitoes, but practically no attention was paid to them, and they have been resurrected and considered significant only since the beginning of the present century.

With the discovery of the agency of microorganisms in the causation of disease, a search soon began for some causative germ of yellow fever. Many microorganisms were found in the course of autopsies and many claims were set forth by investigators. All of these, however, were virtually set at rest by Sternberg in his "Report on the

Etiology and Prevention of Yellow Fever," published in 1890. But a claim made by Sanarelli in June, 1897, for a bacillus which he found in 58 per cent of yellow-fever cases, and which he called *Bacillus icteroides*, received considerable credence. This was found afterwards by several investigators in considerable abundance, but later it was shown by Reed and Carroll that the organism in question is identical with the bacillus of hog cholera and is in no way concerned with yellow fever.

In 1881 Dr. Carlos Finlay, of Habana, proposed the theory that yellow fever, whatever its cause may be, is carried by means of a certain mosquito from man to man. His original paper shows that he had carefully studied the habits of house mosquitoes and had determined all of the factors in the life history of the species now known as the true yellow-fever mosquito, which have since been shown to be essential in its rôle of transmitter of the disease. It was this careful study of the mosquito and the disease, conducted through many years in the most favorable locality, the city of Habana, that gave him a firm conviction that the two were interdependent. On this account his theory has true scientific merit. It was based on intensive study, and not, as had been the case with his predecessors, on vague suspicions. Subsequently he published a number of important papers, in which his views were modified from time to time. He thought out carefully the question of immunization and concluded that this might be brought about by mild infection through the bite of a single mosquito. In one of his papers he published experiments with 100 individuals, producing 3 cases of mild fever. None of the cases, however, was under his full control; and as the possibility of other methods of contracting the disease was not excluded, his claims were not accepted.

In 1900 the facts were determined by scientific methods. An American army being at that time stationed in Cuba, a medical board was appointed by Surg. Gen. Sternberg for the purpose of investigating the acute infectious diseases prevailing in the island. The board consisted of Walter Reed, James Carroll, Jesse W. Lazear, and Aristides Agramonte. Dr. Reed was the chairman of the board. In the course of the work yellow fever naturally received the main measure of attention. The claims of Sanarelli's *Bacillus icteroides* were disproved, and Reed and his associates began a careful and thoroughly scientific investigation of the possibilities of mosquito carriage of the disease. Experiments carried on by the board were as perfect in their methods as it was possible for scientific acumen and hard common sense to make them. Every possible element of error seems to have been guarded against. The final and conclusive tests made during the autumn of 1900 were conducted with a spirit of earnestness, self-sacrifice, and enthusiasm which affected everyone connected with the work, even in the most subordinate positions, private soldiers not only offering themselves for the presumably dangerous tests, but insisting that they should be accepted as subjects for experimentation. Dr. Reed, the master spirit of the investigation, was, moreover, a man above all men for this work, no less in his ability to compel the greatest confidence and enthusiasm than in the absolutely complete manner in which the experiments were conducted. While the work was going on criticism was invited and urged from Habana physicians, from visiting surgeons, and from everyone interested, but so perfect were the plans that it seems impossible that any criticism could have been made.

An experimental sanitary station was established in the open, a mile from Quemados. Two houses were built, tightly constructed, with windows and doors protected by wire screens. In one of these houses soiled sheets, pillowcases, and blankets were used as bedding, and this bedding was brought straight from the beds of patients sick with yellow fever at Habana. For 63 days these beds were occupied by members of the Hospital Corps for periods varying from 20 to 21 days. At the end of this occupation the men, who were all nonimmunes, were taken to quarantine for five days and released. Not one of them was taken ill. All were released in excellent health. This experiment was of the greatest importance, as it demonstrates that the disease is not conveyed by fomites; hence the disinfection of clothing, bedding, or merchandise formerly supposed to have been contaminated by contact with yellow-fever patients is unnecessary. This disinfection work, which hitherto had been carried to the extreme in the case of yellow-fever epidemics in our Southern States, was shown to have been perfectly useless.

In the other house, which was known as the "infected mosquito house," there were no articles which had not been carefully disinfected. The house contained two rooms, and nonimmunes were placed in both rooms. In one room, separated from the other by a wire screen partition, only mosquitoes which had bitten yellow-fever patients were introduced. In the other room they were excluded. In the latter room the men remained in perfect health. In the mosquito room 50 per cent of the persons bitten by infected mosquitoes (that had been kept 12 days or more after biting yellow-fever patients) were taken with the disease, and the yellow-fever diagnosis was confirmed by resident physicians of Habana who were above all others familiar with the disease in every form. Persons bitten by mosquitoes which had bitten a yellow-fever patient within less than 12 days did not contract the disease. In another series of experiments seven persons were bitten by infected mosquitoes by placing the hand in a jar containing the insects, and five of them, or 71 per cent, contracted the disease.

It was also found that yellow fever was produced by the injection of blood from the general circulation of a patient. Subcutaneous injections of 2 cubic centimeters of blood were followed by the disease, and the definite conclusions were reached that the parasite of yellow fever must be present in the general circulation, at least during the early stages of the disease, and that yellow fever may be produced, like malarial fevers, either by the bite of the mosquito or by the injection of blood taken from the general circulation. From these results the important corollary was reached, to quote Dr. Reed's own words:

> The spread of yellow fever can be most effectually controlled by measures directed to the destruction of the mosquitoes and the protection of the sick against the bites of these insects.

The organism that causes the disease has never been discovered. It is doubtless a protozoan, too small to be seen with the microscope, whose life cycle is partly in man and partly in the mosquito.

SUBSEQUENT DEMONSTRATION.

The finality of the work of the American Army commission was almost immediately accepted by sanitarians throughout the Tropics. Measures were at once instituted in the city of Habana, then under American control, looking to the eradication of yellow fever through antimosquito measures. The enormous success of this work, carried on under the direction of Maj. (now Col.) Gorgas, is a matter of history, and by the use of similar methods the same efficient sanitarian has since that time wiped out yellow fever in the Isthmian Canal Zone. Similar work has been done by the sanitary officials in Brazil and in Mexico and other countries.

A striking instance of the value of this discovery was shown during the yellow fever outbreak in New Orleans in 1905. Down to the middle of June of the summer of 1905 this outbreak threatened to parallel the disastrous outbreak of 1878, and even to exceed that disaster in severity. Antimosquito measures were undertaken, however, and pushed with great energy and with much expenditure of funds, the result being a perfectly obvious saving of from 3,000 to 4,000 lives during that summer which would undoubtedly have been lost six years earlier.

REMEDIES.

The general question of remedies for mosquitoes is considered in Farmers' Bulletin 444, and it will therefore be unnecessary to enter upon this subject in this bulletin. Readers are also referred to Farmers' Bulletin 450, on malaria, as related to this general subject.

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Issued July 17, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 548.

STORING AND MARKETING SWEET POTATOES.

BY

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Assistant Horticulturist, Bureau of Plant Industry.

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1913.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington D. C., May 17, 1913.

SIR: I have the honor to transmit herewith a manuscript entitled "Storing and Marketing Sweet Potatoes," prepared by Mr. H. C. Thompson, Assistant Horticulturist, and recommend that it be published as a Farmers' Bulletin to replace Farmers' Bulletin 520, entitled "The Storing and Marketing of Sweet Potatoes."

The results of the work during the past season put in our possession information which makes it desirable to make this change. The great number of inquiries which have been received regarding the best methods of constructing storage houses makes it necessary to give plans and specifications for such buildings, which have been included as a part of the present bulletin.

Respectfully,

WM. A. TAYLOR,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

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STORING AND MARKETING SWEET POTATOES.

INTRODUCTION.

Each year the sweet potato is becoming of greater importance as a money crop in the South. The value of this crop in the United States in 1909 was $34,429,000, 90 per cent of which was produced in the Southern States. The total area devoted to sweet potatoes in the United States increased from 537,000 acres in 1899 to 641,000 in 1909, and the yield increased from 42,500,000 to 52,200,000 bushels. The total value of the crop increased at a much more rapid rate than either the acreage or yield, showing an increase of 78.3 per cent in 10 years.

With better methods of storing and marketing the potatoes, their value could be doubled without increasing the acreage or production. This is especially true in the South, where the potatoes are either rushed on the market at digging time, when the price is low, or stored in outdoor pits or banks, where a large portion decay. Very few of the sweet potatoes stored in pits or banks ever reach the market, for from 25 to 50 per cent spoil and those that remain are not of good quality. Even if the pit or bank method of storage would keep the potatoes it is not economical. Too much labor and expense are required to make these banks every year and to get the potatoes out when wanted for market. Sweet potatoes can be marketed more economically and to much better advantage from storage houses. It is not advisable to open a bank when the soil is wet or the weather cold, as these conditions injure the potatoes and cause them to decay. Outdoor pits and banks can not be depended on. Some years a very small number of the potatoes spoil in banks, while in other years practically the whole crop is lost. The only safe and practicable method of storing sweet potatoes is in a storage house, as the potatoes can be taken out at any time without subjecting them to unfavorable conditions.

To keep sweet potatoes in good condition they must be (1) well matured before digging, (2) carefully handled, (3) well dried or cured after being put in the house, and (4) kept at a uniform temperature after they are cured.

The grower can judge when his sweet potatoes are ripe by breaking or cutting the tubers and leaving them exposed to the air for a few minutes. If the cut or broken surface dries they are mature, but if the surface remains moist they are not ready to be dug. In regions where early frosts occur the sweet potatoes should be dug about the time the first frost is expected, regardless of the stage of maturity of the tubers.

The second essential, careful handling, is of the greatest importance and should be practiced in digging, gathering, hauling, and unloading. The potatoes should be sorted in the field and gathered in padded baskets or boxes to prevent bruising or breaking the skin. The baskets or boxes should be loaded on the wagon, hauled to the storage house, and the potatoes carefully poured into the bins. When they are to be hauled very far a wagon with bolster springs should be used. Sweet potatoes should never be thrown from one row to another, loaded loosely into a wagon body, or hauled in bags, because any of these methods will bruise them and give a chance for disease to enter.

The third and fourth essentials, thorough drying and a uniform temperature, can be secured in a storage house where artificial heat can be supplied. It is essential that the house be constructed in such a way that it can be thoroughly ventilated when necessary, but can be made nearly air tight in cold weather. These requirements are provided for in the type of house described in this bulletin.

It is economy to build a substantial sweet-potato storage house, because it will last longer and require less attention than a cheap, poorly constructed one. It would be possible to keep sweet potatoes in a cheaper and less carefully constructed house, but the attention required and the additional fuel used would soon exceed the cost of the extra care and material required in a better one. The chances of loss are much greater in a poorly built than in a well-built house.

CONSTRUCTION OF A SWEET-POTATO STORAGE HOUSE.

Sweet-potato storage houses may be built of wood, brick, cement, or stone. Wooden houses are preferable because they are cheaper and easier to keep dry. It is difficult to keep moisture from collecting on the walls of a cement, stone, or brick house. The house should be built on posts or piers, so as to allow a circulation of air under it. The "dugout," or a house built partly under ground, should never be used in the South for storing sweet potatoes, because it is practically impossible to keep this type of house dry, and moisture in the storage house will cause the potatoes to rot.

In building a storage house the sills should be placed on posts or pillars 12 to 15 inches from the ground or just high enough for the wagon bed to be on a level with the floor of the house. The size of the house will depend on the quantity of potatoes to be stored. A house 20 by 40 feet, built according to the plans shown in figures 1 to 4, will hold from 2,500 to 3,000 bushels. This type of house may be constructed as follows:

Three rows of pillars should be built, one under each side and one under the center of the house, using cement, brick, or wooden blocks. On the pillars sills 8 by 8 or 8 by 10 inches should be placed and on these 2 by 8 or 2 by 10 inch sleepers. Over the sleepers a rough floor of 1 by 4 or 1 by 6 inch boards should be laid, then a layer of heavy building paper, and over this matched flooring. The walls of the house should be built by placing 2 by 4 or 2 by 6 inch studding every 2 feet. On the outside a layer of 1 by 6 inch boards should be nailed diagonally to brace the wall; over these a layer of heavy building paper should be placed, and then matched siding. The inside of the building should be ceiled with 1 by 6 inch rough boards, then a layer of heavy building paper, and over this matched boards or wainscoting. In the lower South the first layer of boards on the inside may be omitted and the paper tacked to the studding, the matched boards being nailed over this. The sides should be well tied together and for this purpose 2 by 4 inch scantling placed 4 feet apart, so as to be over the partitions for the bins, will be satisfactory. The roof may be made of shingles, roofing paper, tin, or galvanized iron. Galvanized iron is preferable because it is the most durable and lessens danger from fire. Use 2 by 4 or 2 by 6 inch scantling for rafters and make the roof tight, so as to keep out the cold. It is a good plan to put a layer of building or roofing paper over the rafters

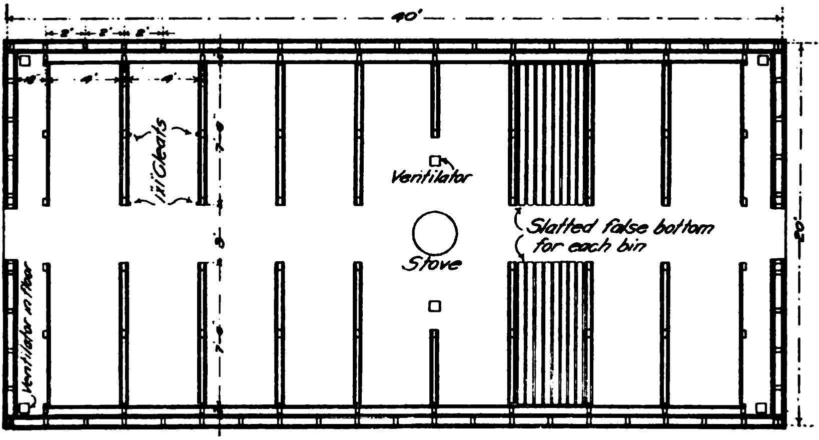

FIG. 1.—Ground plan of a good type of sweet-potato storage house.

under the roofing material. On the inside of the rafters nail a layer of unmatched boards, then a layer of heavy building paper, and over this a layer of matched material.

The space between the walls should be left open, because any material used to keep out the cold will take up moisture. Many storage houses have been built with sawdust, shavings, or similar material between the walls, but this practice should never be followed. Sawdust will take up moisture and when once wet will never dry out. This moisture will keep the house damp and cause the walls to rot. The air space is as good an insulator as the sawdust if the walls are made tight, and they will be if the plans given here are followed.

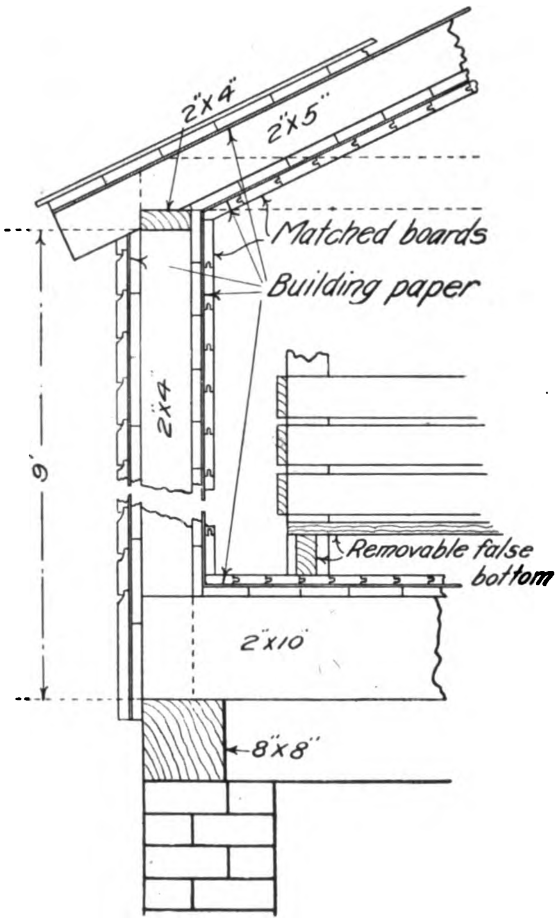

FIG. 2.—Details of construction of a sweet-potato storage house.

Thorough ventilation is necessary in a storage house. To secure this there should be three windows on each side, a door in each end of a 20 by 40 foot house, at least two ventilators through the roof, a ventilator in the floor in each corner of the house and one on each side of the stove. In a smaller house it may not be necessary to have more than one door. In this case there should be a window in the back of the house and a door in front. The bottom of the windows should be within 18 inches or 2 feet of the floor. The windows and doors must be made so as to close tightly to keep out the cold. A good plan is to make the doors and windows like those shown in figure 5. All windows should be made to open from the outside, as the bins will be in the way of opening from the inside. Where glass windows are used, outside shutters are put on, as shown in figure 6, and these should be well padded. Some of the windows should be made of glass, so as to admit light without letting in cold air, as it is necessary to have light when working in the house, and in cold weather the house should not be kept open. All of the openings must be made so they can be closed quickly and tightly whenever necessary.

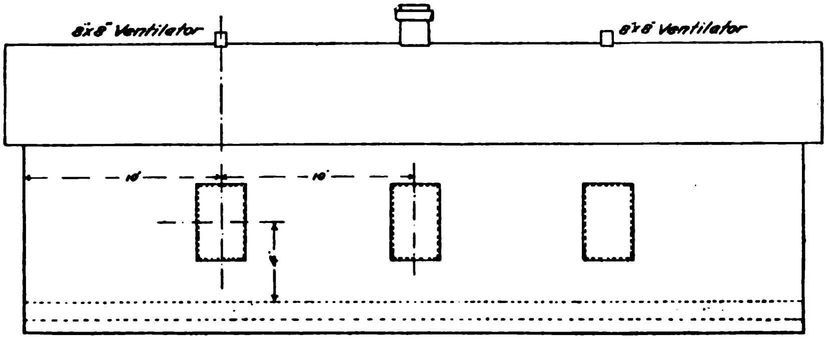

FIG. 3.—Side elevation of a sweet-potato storage house.

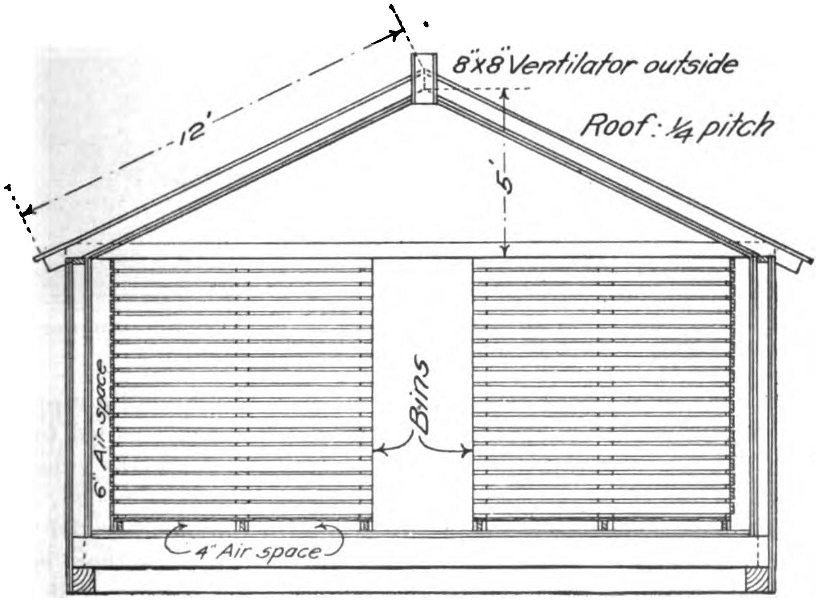

FIG. 4.—Cross section of a sweet-potato storage house.

The ventilators in the roof should extend through the ceiling, so as to carry out the warm air as it rises. Ventilators 8 by 8 or 10 by 10 inches, made of wood, are very satisfactory. These should be provided with a roof to keep out rain and at the bottom end with a tight-fitting shutter, which can be closed in cold weather. The ventilators in the floor may be holes 12 by 12 inches, but they should be provided with tight-fitting covers, so that they can be closed when necessary.

The interior of the house should be arranged for convenience in handling the potatoes. It should be divided into bins of convenient size so constructed as to allow air to circulate around the potatoes. A good arrangement of a passageway and bins is shown in the ground plans, figure 1.

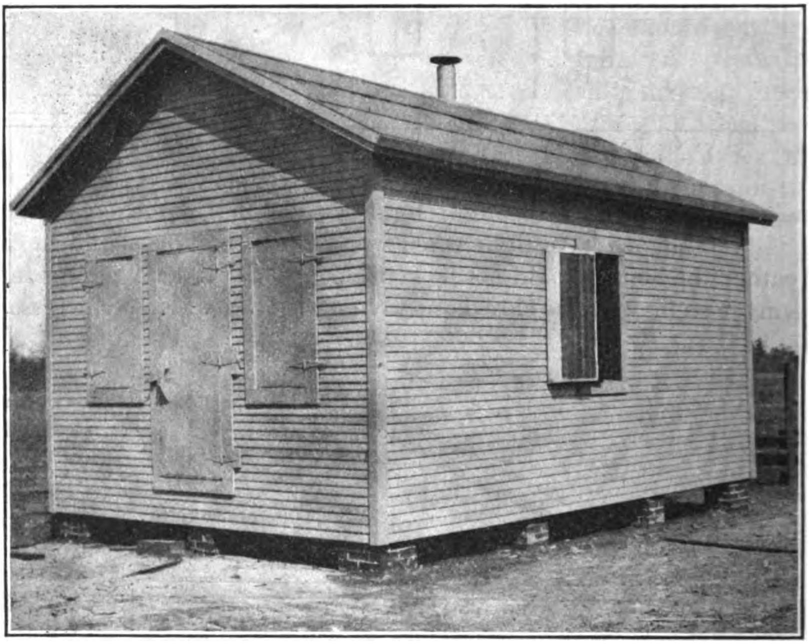

FIG. 5.—A good type of sweet-potato storage house, but more expensive than necessary. This house is 14 by 20 feet and is heated by an oil stove.

The bins are made as follows: For the corner and middle supports 2 by 4 inch scantlings should be set up, the lower end nailed to the floor, and the upper to the crosspieces used for tying the sides together. Over the supports 1 by 4 inch boards should be nailed, leaving a 1-inch space between them. The ends of the bins parallel with the outside wall of the house must be built first, because there is not room enough to work between the bin and the outside wall. In making the floors 2 by 4 inch scantlings should be cut to go across the bin and placed on edge, one near each end and one in the center. To these should be tacked 1 by 4 inch boards, leaving a 1-inch space between them. The bin floor should not be fastened to the floor of the house. If left loose it can be taken out when the house is cleaned and disinfected during the summer. The size of the bins will depend somewhat on the arrangement and size of the house. The bins shown in figures 1 and 4 are 4 feet wide, 7½ feet long, and 8 feet deep, which is a convenient size. There should be a 6 to 12 inch space between the walls and the bins, to allow a circulation of air. It is advisable to slat up both sides of the scantlings between the bins in order to leave an air space between the potatoes in the different bins. The construction here described allows a 4-inch air space between the bins, a 4-inch space under the bins, and 6 inches between the bins and outside walls.

On many farms in the South there are buildings, such as abandoned tenant houses, that could be converted into sweet-potato storage houses at very little expense. Where there are such buildings they should be used rather than to build a new house. These houses will usually need to be ceiled on the inside. For this purpose 2 by 4 inch scantlings should be set against the wall and covered first with building paper and then a layer of matched lumber. The windows and doors should be made tight and ventilators put in where needed. The bins may be made as already described.

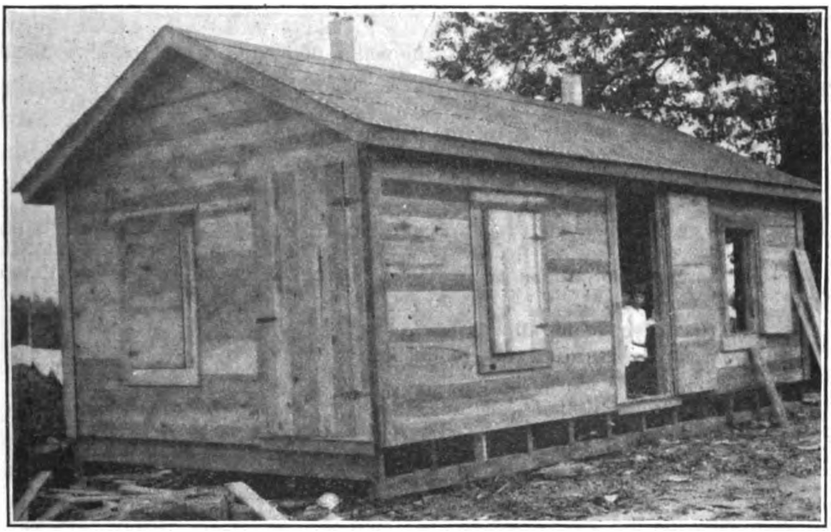

FIG. 6.—A satisfactory sweet-potato storage house, 12 by 24 feet, costing about half as much as the one shown in figure 5.

MATERIAL REQUIRED FOR A 20 BY 40 FOOT STORAGE HOUSE.

It is not practicable to give the cost of a sweet-potato storage house, because of the difference in the price of materials and labor in different sections of the country. Given the amount of material required it will be easy for anyone to secure estimates on the cost of the materials in his locality. For a house 20 by 40 feet built after the plans given in this bulletin it will require approximately the following materials:

	Board feet.	
Lumber for storage house proper:		
Sills, 8 pieces 8 by 8 inches by 20 feet	860	
Sleepers, 21 pieces 2 by 10 inches by 20 feet	700	
Studding, 64 pieces 2 by 6 inches by 9 feet	576	
Rafters, 42 pieces 2 by 6 inches by 12 feet	504	
Tying sides, 10 pieces 2 by 4 inches by 20 feet	135	
Plates, 6 pieces 2 by 6 inches by 20 feet	120	
Material, rough boards, miscellaneous lengths, for inner walls, floor, etc	4,500	
Flooring	960	
Dressed tongue-and-groove material	2,600	
Drop siding	1,500	
Total number of board feet for the walls, floor, and ceiling		9,560
Lumber for bins:		
Bin supports, 60 pieces 2 by 4 inches by 8 feet	320	
Floor supports, 60 pieces 2 by 4 inches by 4 feet	160	
Sides and ends of bins, 1 by 4 inches, miscellaneous lengths	3,000	
Floor of bins, 1 by 4 inches, miscellaneous lengths	560	
Total number of board feet for bin material		4,040
Total amount of lumber		13,600

Miscellaneous material:

4,500 square feet of building paper.
10 squares of galvanized-iron roofing.
1 stove.
1,000 bricks for chimney and pillars.
8 pairs of hinges for doors and windows.
200 pounds of nails.
2 doors.
6 windows.
1 flue plate and hanger.

VARIETIES OF SWEET POTATOES FOR MARKET.

The varieties of sweet potatoes to grow depend on the market to be supplied. The northern and eastern markets demand a dry, mealy potato, such as the Big-Stem Jersey, including the so-called Improved Jersey, Yellow Nansemond, Early Carolina, Gold Coin, and others. The markets of the South demand a moist, sweet root. Among the varieties most in demand in the South are the Nancy Hall, Dooley Yam, Pumpkin Yam, and Triumph. The southern farmers should supply their own markets before trying to ship their potatoes to the northern markets. During the late winter and spring the larger cities of the South get sweet potatoes from regions in the North, because they can not secure the southern varieties at that time. With storage houses, these markets could be supplied with southern-grown potatoes throughout the season. The markets of the West will take the moister fleshed potatoes grown in the South, and a good trade could be built up in this region.

While the varieties of sweet potatoes grown in the South are preferred by the southern people, the dry, mealy roots sell best in the markets of the North. The grower should aim to give the consumers what they want, and when growing sweet potatoes for northern markets the Big-Stem Jersey should be grown, regardless of the grower's preference.

HARVESTING SWEET POTATOES.

Careful handling is one of the essentials in keeping sweet potatoes, and there is no more important place to practice it than in the field at digging time. The implement used to dig sweet potatoes should be one that does not cut or bruise the roots. One of the best types of diggers is a plow with rolling colters on the beam to cut the vines and with rods attached to the moldboard to free the roots from the soil and vines. (Fig. 7.) After the potatoes are dug they should be scratched out by hand and allowed to remain exposed long enough to dry off. The digging should be done, if possible, when the weather is bright and the soil is dry.

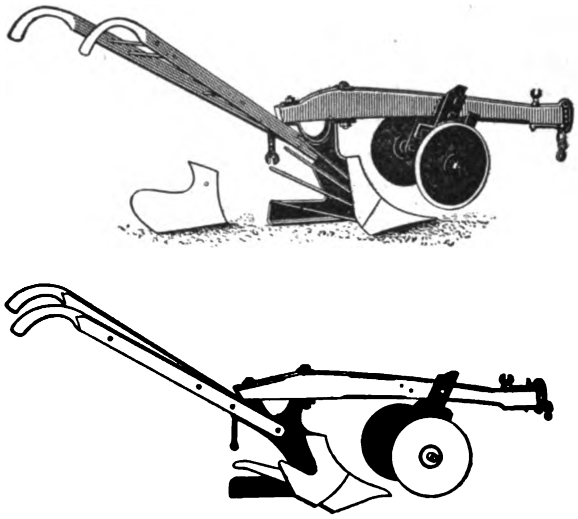

FIG. 7.—Special plows used for digging sweet potatoes.

The potatoes should be graded in the field in order to reduce the cost of handling to a minimum. A good plan is to go over the rows and pick up the sound, marketable potatoes in one basket, then gather all of the seed stock in another basket or box, and the injured ones in still another. These lots should be stored in different bins. By following this method it will not be necessary to grade the potatoes at the storage house and will thus save time and reduce the cost of handling. The potatoes should be poured into the bins as carefully as possible, to prevent bruising. Sweet potatoes can be stored in boxes, hampers, baskets, or bins with equally satisfactory results. The preference of the individual grower will determine the method to be employed.

Each year after the sweet potatoes have been marketed the house should be thoroughly cleaned and disinfected before being used again. All dirt and refuse should be cleaned out and all parts of the interior sprayed or washed thoroughly with a solution of formalin (1 pint of formalin to 10 or 15 gallons of water). Diseased roots should not be thrown on the manure pile or on land to be used for sweet potatoes, the safest plan being to burn them.

In filling the storage house the workmen should begin at the back end of the bins and pour a layer of potatoes about 2 feet deep in all of the bins rather than fill one bin at a time. If the bins are 8 or 10 feet long it is a good plan to divide them into two parts. By nailing cleats to the middle support of the bins, as shown in figure 1, the partition can be raised as the bins are filled. The partition boards should have some space between them to allow free circulation of air. A 1-inch block between the boards will be satisfactory to separate them. By dividing the bins in this way the back of the bin can be filled without walking over the potatoes in the front part. When taking the potatoes out, those in one section of a bin can be removed without disturbing the remainder. This is very important where the potatoes are sold in small quantities.

While the potatoes are being brought in, a fire should be kept up in the storage house to dry off the moisture. A temperature of 80° to 85° F., with plenty of ventilation, should be maintained for 10 days or 2 weeks, depending on weather conditions and the variety of potatoes. Ventilation is absolutely necessary, and even if it is not possible to keep the temperature up to 80° F. it is necessary to leave the ventilators open, so as to drive out the moisture-laden air. The house may be closed at night, and should be kept closed on cloudy days, but if moisture begins to deposit on the walls or ceiling the house should be opened and a fire started to drive off the moisture. The air inside the house should be kept warmer than the outside air during the curing period. This will prevent moisture from being deposited on the walls. As the air warms it expands and takes up moisture. When it cools it contracts and gives up its moisture. This makes it important to get the moisture-laden air out of the house by ventilation. When the potatoes are thoroughly dried or cured the temperature should be gradually reduced to 55° F. and kept as near that point as possible during the remainder of the storage period. If the temperature goes below 48° a fire should be made or the house opened in the middle of the day whenever the temperature on the outside is high enough. When the temperature goes above 60° F. the house should be opened in the cool of the day to lower the temperature to 54° or 55° and then closed. The house should have some ventilation every day. In mild weather the ventilators in the roof may be partly open all the time, but they should be closed in cloudy or cold weather.

A small house can be heated with a sheet-iron stove that will burn knots and other pieces of wood. Coal stoves may be used if preferred, but the air-tight wood stoves will serve the purpose. It requires a longer time to get up heat with a coal stove than with a wood stove, and this is one disadvantage of the former. Many times all that is necessary to raise the temperature a few degrees is to start a little wood fire. In a commercial storage house a hot-water heater with pipes around the walls would be preferable to a stove, but even a house that will hold 10,000 to 25,000 bushels of potatoes may be heated with a good stove. The location of the stove in the house depends on the size of the house and the direction of the cold winds. Ordinarily the stove should be near the center of the house, but if the cold wind strikes one end the stove should be in that end. Some storage houses have a small stove in each end, and this is the best arrangement in a long house. Others have a stove in one end, with the pipe entering the chimney at the other end. Considerable open space should be left around the stove to prevent the potatoes from being injured by excessive heat.

MARKETING SWEET POTATOES.

One reason why southern farmers have not received good prices for their sweet potatoes is that they have not used proper methods of handling and marketing. In many cases the potatoes are badly bruised and cut in digging, are put in bags or rough barrels without grading, and are rushed on the market when there is an oversupply. The secrets of success in getting high prices are (1) to carefully grade, clean, and pack the product and (2) to put it upon the market when there is a good demand. The greatest demand for sweet potatoes is, as a rule, from the middle of December to the middle of March.

When the potatoes are to be marketed they must be carefully graded, no matter how well it had been done when they were put in the house. The market demands a medium-sized, uniform type of sweet potato, free from bruises or decayed spots. In grading, the large, overgrown, and the crooked, broken, or bruised roots should be kept at home for feeding or for canning. The best potatoes will bring a higher price when separated from the culls. Two market grades are sometimes made—the "extra selects" or "primes" and the "seconds" or "pie stock"—but the southern farmer will do well to make just one market grade and keep the others for feeding to his live stock.

After carefully grading the potatoes they should be put in clean, neat, attractive packages. Bags should never be used, as the potatoes become badly bruised when handled in this way. The standard veneer potato barrel with a burlap cover, shown in figure 8, is usually used in summer or autumn, but for winter shipment the double-headed stave barrel or tight box is used. The smaller type of package, such as the bushel hamper (fig. 9), bushel box, or basket, is becoming more popular each year. A neat and attractive package of well-graded potatoes will bring a good price almost any time, even when the market is overstocked with inferior goods.

Potatoes shipped during the winter must be protected from the cold. When a sweet potato becomes chilled its quality is impaired and decay soon sets in. In cold weather the package should be covered with paper and the cars heated to prevent chilling the potatoes. Some find it advantageous to line their baskets and barrels with paper.

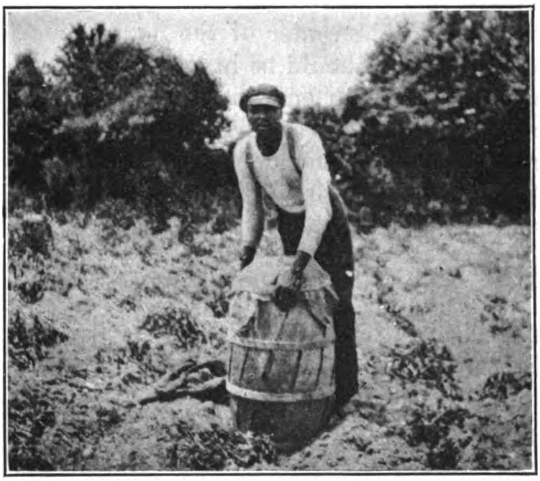

Fig. 8.—Standard potato barrel, commonly used for the shipment of sweet potatoes during the summer months.

SUMMARY.

The value of the sweet potato has increased about 80 per cent in the last 10 years. With better methods of storing and marketing the present value could be doubled.

Sweet potatoes can be kept satisfactorily in a storage house where the temperature and moisture conditions can be controlled.

Sweet potatoes to keep well must be well matured, carefully handled, thoroughly cured, and kept at a uniform temperature while in storage.

Thorough ventilation is essential during the curing period.

The temperature should be kept at about 80° or 85° F. during the curing period and reduced gradually to 55° after the potatoes are cured.

Fluctuations of temperature should be avoided throughout the storage period.

The varieties of sweet potatoes that the markets demand should be grown.

The potatoes should be carefully graded, cleaned, and packed in neat and attractive packages.

Sweet potatoes should never be marketed in bags or in bulk.

Veneer barrels or bushel hampers are desirable packages to use during mild weather and double-headed stave barrels or tight boxes in cold weather.

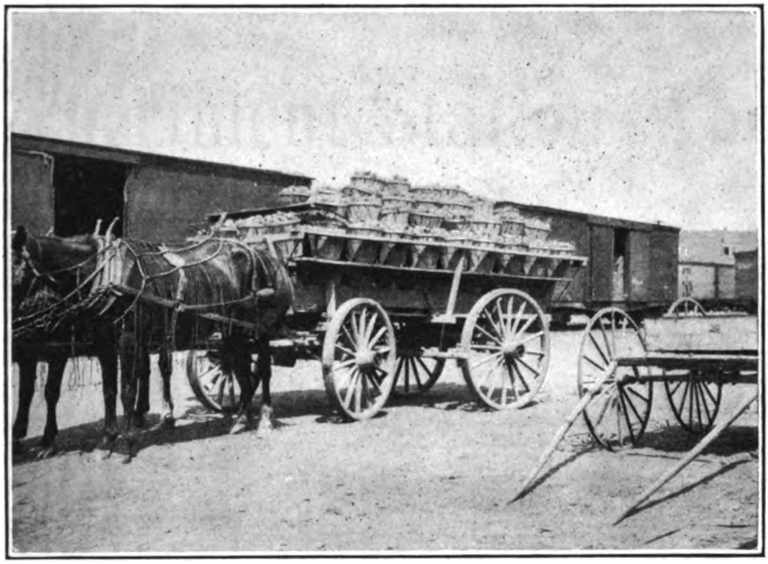

FIG. 9.—Wagon adapted to hauling sweet potatoes from the field to the storage house or shipping point,

With the growing demand for sweet potatoes there is every inducement for the southern farmer to adopt better methods of growing and marketing, so as to make the sweet potato a more important money crop.

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THE MEADOW LARK.
EGG PRODUCTION.
SPROUTING OATS FOR POULTRY.
CARBOLIC ACID FOR CONTAGIOUS ABORTION.
COOLING CREAM WITHOUT ICE.

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EXPERIMENT STATION WORK.

Edited by W. H. BEAL and the Staff of Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from the published reports of the agricultural experiment stations and kindred institutions in this and other countries. The chief object of these publications is to disseminate throughout the country information regarding experiments at the different experiment stations, and thus to acquaint farmers in a general way with the progress of agricultural investigation on its practical side. The results herein reported should for the most part be regarded as tentative and suggestive rather than conclusive. Further experiments may modify them, and experience alone can show how far they will be useful in actual practice. The work of the stations must not be depended upon to produce "rules for farming." How to apply the results of experiments to his own conditions will ever remain the problem of the individual farmer.—A. C. TRUE, Director, Office of Experiment Stations.

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EXPERIMENT STATION WORK.[1]

THE FARM WATER SUPPLY.[2]

Nothing is more essential to the health and comfort of the farm home than a plentiful and wholesome water supply, and yet it is one of the everyday necessities most commonly neglected or inadequately provided for. As M. L. Fuller, of the United States Geological Survey, points out, "farms, which are generally remote from towns, cities, or other areas of congested population, seem to be almost ideally situated for obtaining pure and wholesome water. In reality, however, polluted water is exceedingly common on them, and typhoid-fever rates are usually greater in country districts than in cities. Typhoid fever is now almost universally believed to be transmitted solely through drink or food taken into the stomach, and is especially liable to be communicated by polluted waters obtained from shallow wells near spots where the discharges of typhoid patients have been thrown upon the ground and subsequently carried down through the soil and into the wells, and it is doubtless principally this fact that makes the disease so common in farming regions."

The germs of various diseases may be transmitted by polluted water, some of them being so uniformly transmitted through this means that they are known as "water-borne" diseases. These include especially dysentery and other intestinal disorders in addition to typhoid fever. That deplorably insanitary conditions as regards the farm water supply very widely prevail is well established, but it has been difficult to bring about the general adoption of methods which would easily remedy these conditions. As the country becomes more thickly settled and new industries are established, the danger of pollution of the natural water supplies is vastly increased and the need of greater care in protection of wells and other sources of supply becomes more urgent.

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[1] A progress record of experimental inquiries published without assumption of responsibility by the department for the correctness of the facts and conclusions reported by the stations.

[2] Compiled from North Dakota Sta. Bul. 66; Oklahoma Sta. Buls. 66, 67; Canada Expt. Farms Rpts. 1911, p. 201; 1912, p. 167; U. S. Dept. Agr., Bur. Plant Indus. Bul. 154; U. S. Geol. Survey, Water-Supply Paper 255; Univ. Ill. Bul., 7 (1909), No. 2, p. 78; Ann. Rpts. Ind. Bd. Health, 27 (1908), p. 345; 29 (1910), p. 349; Univ. Mo. Bul., 2 (1910); Reprint from Pub. Health Jour., State Med. and Sanit. Rev., 1912, April; Sci. Amer., 107 (1912), No. 2, p. 33; Engin. and Contract., 39 (1913), No. 14, p. 394; Municipal Jour., 34 (1913), No. 15, p. 524. See also U. S. Dept. Agr., Farmers' Buls. 73, p. 3; 296, p. 5.

Investigations made by K. F. Kellerman and H. A. Whittaker, of the Bureau of Plant Industry of this department, in cooperation with the Minnesota State Board of Health, showed that of 79 carefully selected and typical farm water supplies in Minnesota, mainly well waters, 20 were good and 59 were polluted, usually because of careless or ignorant management, and generally as a result of poor location or lack of protection against surface wash or infiltration. The rivers, surface reservoirs, and cisterns investigated were found to be polluted to such an extent that it is considered doubtful whether satisfactory supplies can be secured for household use from such sources.

A large proportion of the farm water supply comes from shallow wells, which are particularly subject to contamination. Deep wells are safer, but are not entirely free from danger of pollution.

F. T. Shutt, of the Canada Experimental Farms, concludes from an examination of several thousand samples of water used on farm homesteads in Canada that "probably not more than one-third of them are pure and wholesome."

> The source of the supply, both for man and beast, on the majority of farms is the shallow well that merely collects "ground water," the soakage from the surrounding soil. Too often convenience alone is consulted in locating the well and as a consequence we find it in the barnyard or dangerously near the privy or other source of contamination. After a few years, even on new homesteads, the water finding its way into such wells will be seriously polluted. These waters are no doubt the cause in many instances of ill health on the farm, and at times we have been able to show that they are directly responsible for an outbreak of typhoid fever.

H. E. Barnard and J. H. Brewster, of the Indiana Board of Health, found in an examination of the rural water supplies in that State that "of the private rural water supplies examined, 177 were deep wells, 411 shallow wells, 5 ponds, 40 springs, and 27 cisterns. One hundred and sixteen of the deep-well waters were of a good quality, 45 were bad, and 16 doubtful. But 159 of the 411 shallow-well waters were potable, 209 were unequivocally bad, and 43 were of doubtful quality." A large percentage of the waters used by the families in which typhoid fever had occurred was unequivocally bad.

E. Bartow found in a water survey of Illinois that three-fourths of the shallow wells of the State were contaminated and possibly dangerous. He states that, where it is possible to obtain a satisfactory water supply by means of driven or bored wells, such wells are much to be preferred to the dug wells. The reasons for this are illustrated in figure 1. In a dug well, as indicated in the illustration, the casing is usually either stone or brick, and such a casing allows water to seep in through its entire depth. In case of a drilled, driven, or bored well carefully cased there is no chance for water to enter the well above the strainer until after it has passed through a layer of earth equal in thickness to the distance from the surface to the top of the strainer, the earth thus serving as a natural filter. In some cases, as shown in the figure, the drilled, driven, or bored well passes through a layer of earth through which water will not pass, and therefore has additional protection from surface contamination.

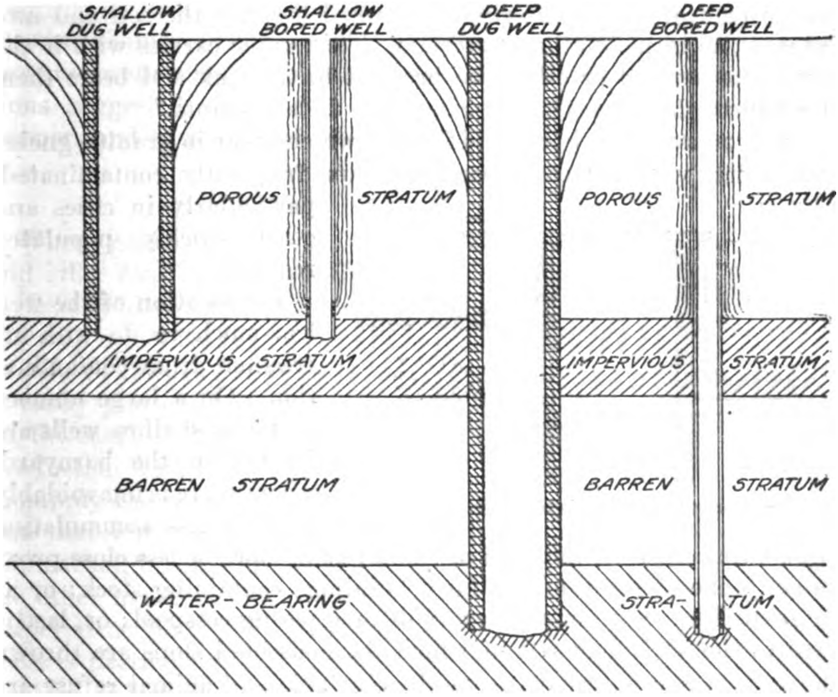

Fig. 1.—Driven and dug wells, showing relative danger of drainage contamination.

Prof. Bartow proposes as a further means of protection for shallow wells that the earth be excavated for 4 feet outside of the regular casing and to a depth of 4 feet, that a coat of water-proof Portland cement be placed over this casing, and that the bottom of the excavation, which should be at least 4 feet deep, be covered with several inches of the cement, having a raised portion at the other edge where the water will collect and be carried away from the well by means of a tile drain, as is shown in figure 2. This arrangement would prevent surface water that has not passed through at least 4 feet of earth from gaining access to the well.

As regards the quality of water from different soils and strata, M. L. Fuller states that in general waters from sand and gravels, if taken from a considerable distance below the surface, are safe to use. Waters from clay are likely to be mineralized, but are as a rule free from contamination. Waters from sandstone, conglomerate, quartzite, shale, and slate are generally free from contamination. Waters from limestone, however, particularly in the vicinity of buildings or settlements, are frequently contaminated and unfit for use "because of the fact that the water falling on the surface as rain often plunges directly through basins or sinks into the underground channels instead of slowly filtering downward through the soil and into the rock, as in most other materials. This water carries with it the impurities washed or otherwise brought to the sink and bears them along through underground passages to distant points."

On accounte of the joints and fissures which occur in granite, gneiss, and schist, waters from these rocks are frequently contaminated, particularly in cities and other thickly populated regions.

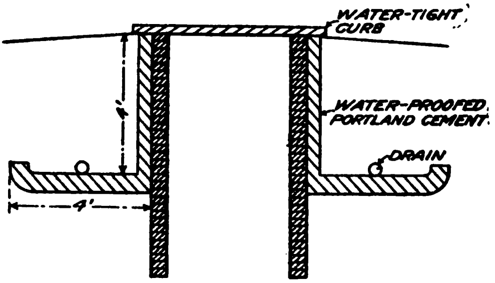

FIG. 2.—Proposed method of protection of dug wells.

The location of the well has much to do with its freedom from contamination. On a large number of farms shallow wells are located in the barnyard, where there is unavoidably more or less accumulation of manure; or under the barn or stable; or in more or less close proximity to one or other of the farm buildings containing stock; or at no great distance from a privy vault or leaching cesspool; or, lastly, close to the back door out of which the household slops are thrown and near which only too frequently vegetable and animal refuse are allowed to accumulate and decompose.

It is obvious that the wells should be located high enough above the farm buildings to secure good surface drainage away from the well and as far removed from all possible sources of contamination as convenience will permit, and in locating the well and providing for its protection against pollution account should be taken of the fact to which K. A. McVey, of the engineering experiment station of the University of Missouri, calls attention, that the quality of the water in a shallow well may depend to some extent upon the rate at which it is pumped. He states that the well may be located higher than the surrounding farm buildings and sources of contamination, yet when a large quantity of water is pumped from it the underground conditions may be altered. Not only the water in the well but the surface of the underground water sheet for some distance around the well may be lowered, the distance increasing with the amount of pumping, so that while there may be no source of contamination within the zone affected by ordinary pumping, unusually heavy pumping may draw contamination from a distance.

While conditions are undoubtedly bad, it is believed, as Kellerman and Whittaker state, that "the protection of farm supplies by common-sense methods obvious to anyone who will try to discover the dangers incident to his own water supply would render safe the majority of the farm supplies which are now polluted," and if, as Bartow points out, "care be taken to use the deep drilled, driven, or bored wells when such can be used, and to take the special precautions suggested where dug wells are a necessity," the health of farmers and of people in general will be improved.

STORAGE OF POTATOES.[1]

Where potatoes are grown extensively and temperature, rainfall, and other conditions are especially favorable for local storage, there is usually decided economic advantage in storing a large part of the crop awaiting favorable market conditions. As R. M. Dolve, of the North Dakota Experiment Station, points out, the potato market is easily glutted, and when large quantities of potatoes are thrown on the market at one time "the price often falls below the cost of production for a time, even though the total crop may be insufficient to supply the demand for the year. For this reason potato growers find that warehouses, which will enable them to take advantage of the market, become an indispensable part of their equipment." On the other hand, as C. L. Fitch and E. R. Bennett, of the Colorado Experiment Station, state, "in those districts where the winter climate is particularly severe, and where it is difficult because of cold weather or bad roads to take the potatoes from storehouse to market, there is more of a tendency to sell potatoes direct from the field regardless of price at digging time, and in districts where the rainfall is excessive there is also the objection that storage houses are not so easily kept dry as in the arid regions of the West." Methods of storage have probably been most highly developed in the potato-growing regions of the West. The potato growers of those regions "have taken advantage of the favorable conditions for storing, and a characteristic and unique system of storing has been developed. * * * The history of this system shows that it is not an invention, but a gradual growth from the idea of storing in pits to the perfected, ventilated potato cellars."

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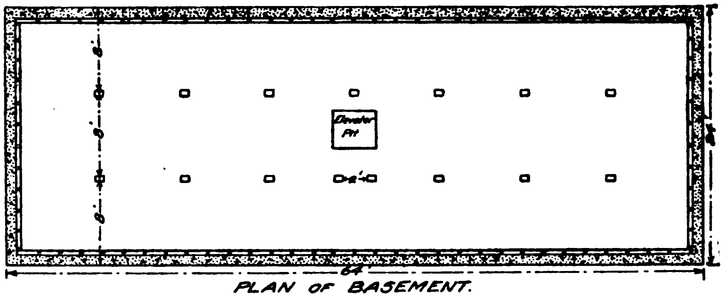
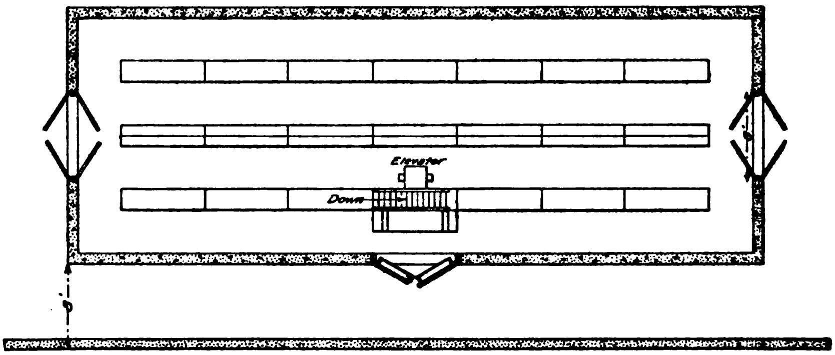
[1] Compiled from Colorado Sta. Bul. 175; North Dakota Sta. Bul. 101.

The proper construction of a potato warehouse or cellar involves a careful consideration of temperature, ventilation, light, drainage, convenience, durability, and cost. The ideal temperature to be maintained is just above freezing, or about 34° F. With good management the temperature can be held within 2° above or below 34° throughout the greater part of the winter, can be brought down to this point quickly in the fall, and can be kept from rising very much above it in the spring for a long time. Well-insulated construction, a properly drained location, and good ventilation are essential in maintaining the proper temperature.



PLAN OF BASEMENT.



PLAN OF WORKFLOOR.

FIG. 3.—Floor plans of basement type of potato warehouse having a capacity of 10,000 bushels.

Ventilation * * * is important, but is usually secondary to correct temperature and is ordinarily sufficiently accomplished in connection with air movement secured in proper temperature control. * * * In the fall the ground is warmer than the night air. * * * In the spring the ground is colder than the air except in the cool of the night and early morning. * * * On many fall and winter days doors need to be left open or ajar until bedtime, and in the spring doors must be kept tightly shut all day and can not be opened until bedtime, and should be closed soon after sunrise. * * *

Light is important, and ventilators should serve also the purpose of windows. Darkness is demanded for table stock because greening by light develops the acrid taste characteristic of exposed potato tissue. On the other hand, light combats disease in seed potatoes, toughens the skins, and is a check to excessive sprouting. Cellars should have light in the spring without warmth.

Light and ventilation tend to remove excess moisture from the walls and to keep the air fresh and dry.

A knoll is the best place to locate a potato cellar, as it can be placed well into the earth and still have good drainage. Locations where water may collect and run into the cellar should be avoided.

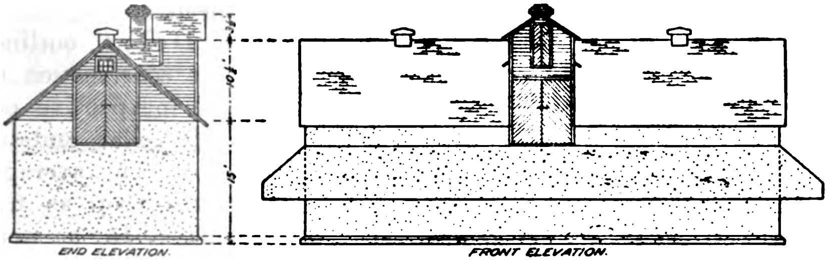


FIG. 4.—End and front elevations of the basement type of potato warehouse.

Potato storage structures may range from a mere pit in the ground to a durable storage house of wood, stone, or concrete, equipped with elevators, carriers, sorters, and other machinery. The choice should be governed by the size of the industry, the available location, and the quantity, quality, and price of available building material. The storage space required may be estimated from the fact that "each square foot of floor space within a cellar will carry 200 pounds of potatoes piled 5 feet deep, or 240 pounds per square foot 6 feet deep. Thus a cellar 50 by 100 feet will hold 1,000,000 or 1,200,000 pounds

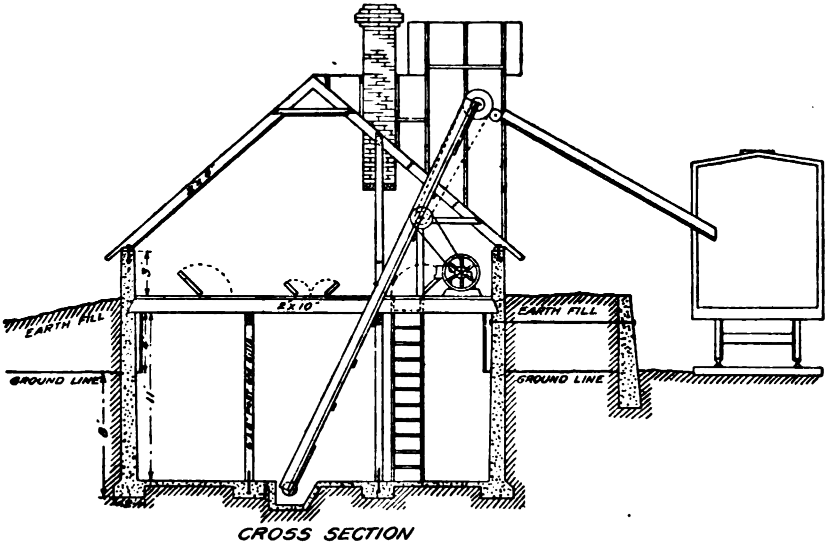
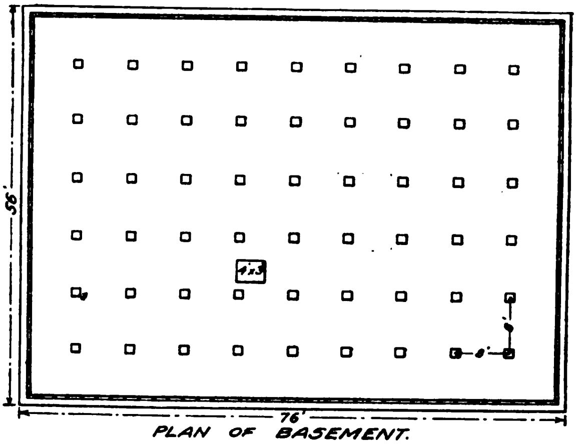


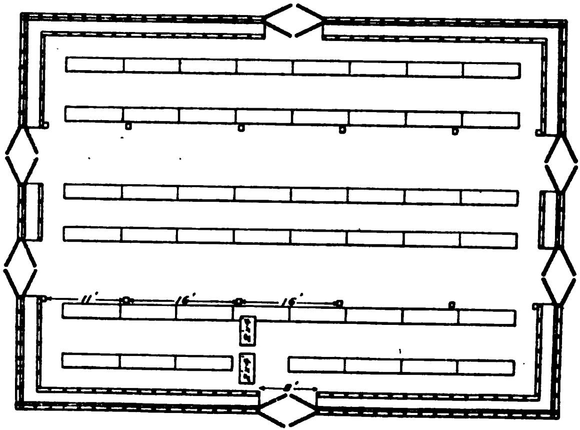
FIG. 5.—Cross section of the basement type of potato warehouse.

of potatoes, with the driveway filled. It is wise to have a cellar large enough to care for the crop if piled 4 feet deep."

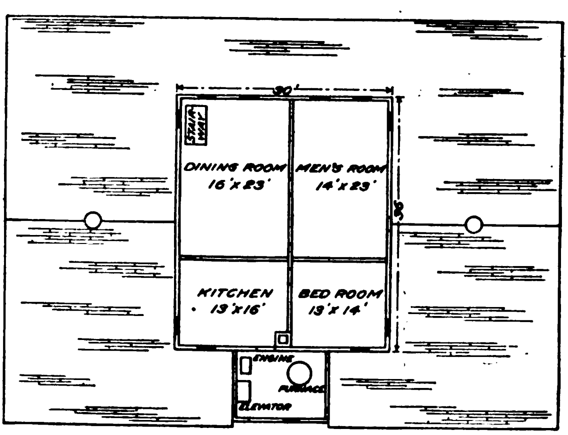
Dolve outlines the construction of an inexpensive potato cellar, suitable for an average-sized crop as follows: In a well-drained location a trench may be excavated 4 or 5 feet deep, 8 or 10 feet wide, and as long as necessary. Light logs or poles can be used for rafters in lieu of regular building timber, but the ends of the rafters should butt against a board or plank placed in a trench along either side of the cellar to hold them in place. The roof need be given a pitch merely sufficient to shed water and to insure sufficient strength, and the boards covering the roof may be spaced an inch or more apart to save lumber, and any cheap boards or slabs not suitable for building



PLAN OF BASEMENT.



PLAN OF WORKFLOOR.



PLAN OF SECOND FLOOR

FIG. 6.—Floor plans of potato warehouse providing storage in both basement and superstructure with a capacity of about 50,000 bushels.

purposes may be used. This roof should be covered with earth to a depth of 18 inches, placing firm sod on top. Small gutters or ditches should be dug along either side to carry away the water shed by the roof, and trap doors large enough to permit the passing of a sack should be conveniently arranged in the roof for filling and emptying the cellar. These openings must be filled with straw or burlap, with a board covering on top during winter. A round sheet-iron ventilator 8 to 12 inches in diameter and provided with a cover for closing, when necessary, should be placed in a ridge in the roof to insure adequate ventilation.

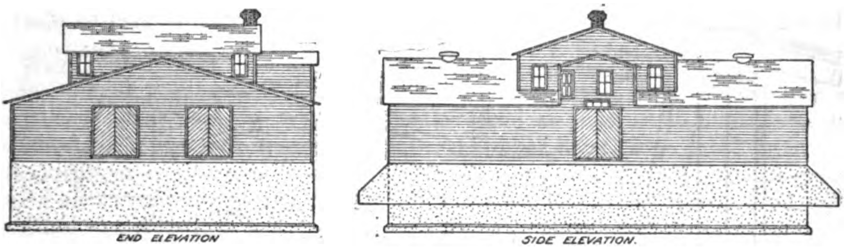


Fig. 7.—End and side elevations of the 50,000-bushel potato warehouse.

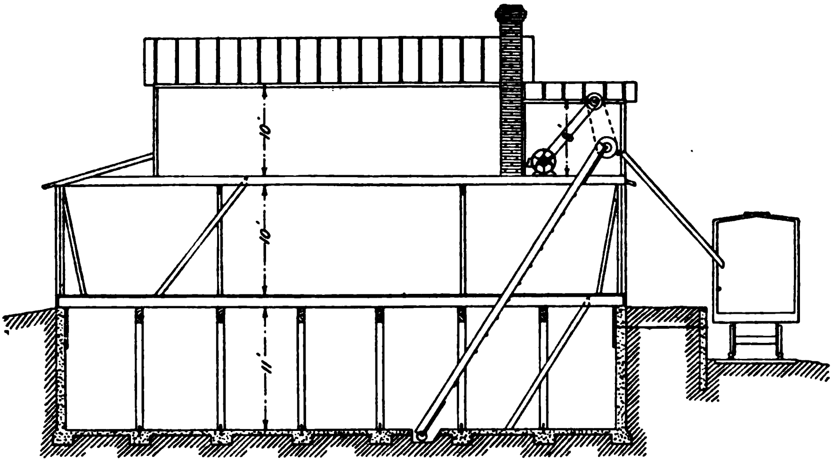


Fig. 8.—Cross section of the 50,000-bushel potato warehouse.

Where the potato-growing industry is conducted on an extensive scale a larger and more durable structure is necessary. Such a structure may be adapted for the use of an individual industry or for neighborhood storage purposes. Figures 3, 4, and 5 are plan, elevation, and cross-section drawings submitted by Dolve of a warehouse of the basement type, having a capacity of 10,000 bushels when filled 10 feet deep. This structure is of wood and concrete, and is equipped with a loading chute and an engine-driven sack elevator.

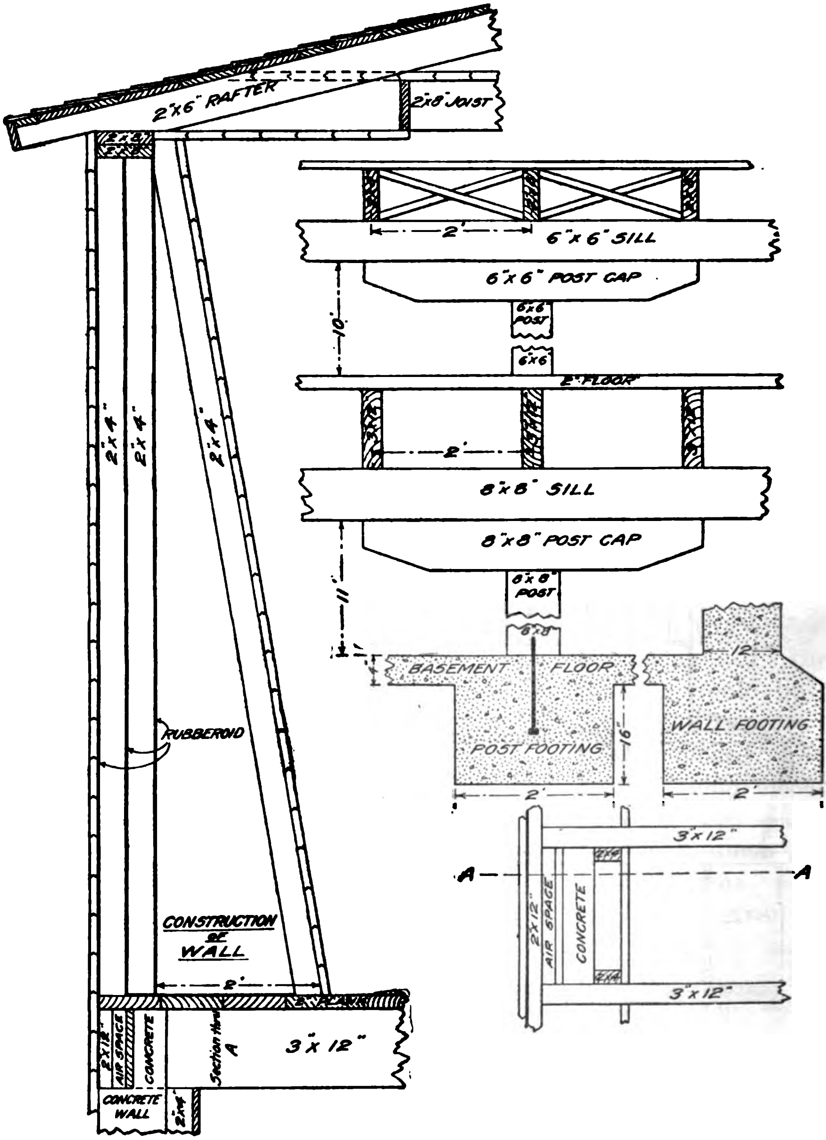


FIG. 9.—Details of construction of the 50,000-bushel potato warehouse.

Figures 6, 7, 8, and 9 are plan, elevation, cross-section, and detail drawings of a warehouse providing storage in both basement and superstructure, and having a capacity of about 50,000 bushels. The structure is of wood and concrete, and is equipped with elevating and conveying machinery. It is particularly adapted for storage and handling of potatoes on a very large scale.

Dolve estimates that the cost of a large first-class potato warehouse will amount to about 10 cents per bushel of its storage capacity. Fitch and Bennett estimate that the cost of construction of the best grade cellars is about 20 cents per hundredweight of potatoes stored.

With a permanent roof over the dirt roof, the cost will be at least 5 cents more, and if a grower wishes to provide for seed-potato storage and have a handsome cellar for sales purposes he may spend as much as 30 cents per hundredweight of potatoes to be stored. On the other hand, with cheap construction, without much regard to permanence, and with the use of farm labor, as little as 7 cents per hundredweight on a large cellar may provide good safe storage. Interest and sinking fund on this basis make the cost of cellar as a minimum 1 cent per hundred of capacity per year. * * * It pays best even with present prices of material to build strongly but cheaply, expecting to build over again when required.

THE MEADOW LARK FROM THE FARMER'S STANDPOINT.[1]

As stated in a recent farmers' bulletin of this department[2] there are two species of meadow larks in the United States—one (*Sturnella magna*) common in the eastern United States and the other (*S. neglecta*) occurring in the western United States. They resemble each other closely in plumage and habits, though differing much in song, the song of the western bird being loud, clear, and melodious, while that of the eastern species is feebler and loses much by comparison.

In many localities the meadow lark is classed and shot as a game bird. From the farmer's standpoint this is a mistake, since its value as an insect eater is far greater than as an object of pursuit by the sportsman. Both the boll weevil, the foe of the cotton grower, and the alfalfa weevil are among the beetles it habitually eats. Twenty-five per cent of the diet of this bird is beetles, half of which are predaceous ground beetles, accounted useful insects, and one-fifth are destructive weevils. Caterpillars form 11 per cent of the food and are eaten in every month in the year. Among these are many cutworms and the well-known army worm. Grasshoppers are favorite food and are eaten in every month and almost every day. The vegetable food (24 per cent of the whole) consists of grain and weed seeds.

Recent studies of the western meadow lark, reported by H. C. Bryant, of the California station, show that while this bird may do considerable damage in destroying sprouting grain, it also consumes large quantities of destructive insects, and when the benefits are balanced against the injuries "there remains no doubt that the bird deserves protection and encouragement. Its value as a destroyer of injurious insects far exceeds its detriment as a destroyer of sprouting grain. The value of a western meadow lark living to one dead is as 5 pounds of insects (mostly injurious) and ½ pound of weed seeds is to 1¾ pounds of grain, a considerable part of which is made up of wild oats and waste grain." Another important point in favor of the birds is that they "turn their attention to the insect most abundant, thereby increasing their efficiency at the time of an insect outbreak. They bear an important relation to grasshopper outbreaks, and to other insect outbreaks as well."

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[1] Compiled from California Sta. Bul. 236; U. S. Dept. Agr. Yearbook 1895, p. 419.

[2] U. S. Dept. Agr., Farmers' Bul. 513, p. 19.

> A strong point favoring the protection of the western meadow lark is to be found in the fact that the only real damage caused (that to sprouting grain fields) can be largely prevented by planting grain deeply and drilling instead of broadcasting, two measures highly advocated by all agricultural experiment stations as favoring larger crops.

EGG-LAYING CONTESTS AND BREEDING FOR EGG PRODUCTION.[1]

The results of some of the egg-laying contests which have recently been carried on emphasize many important principles in egg production, and since there is at the present time an endeavor among poultrymen to produce a maximum amount of eggs for table purposes, with less attention, possibly, to the production of market poultry in the form of broilers and roasters, it would seem that the more important facts brought out in the contests contain valuable lessons for many.

T. E. Quisenberry, who conducted a contest in Missouri, states from the results obtained that apparently there is no variety or breed which far excels other varieties or breeds in general use as far as egg production is concerned.

> More depends upon the strain or breeding as to the number of eggs a variety will produce than upon the variety itself. Some hens have a born tendency to lay and others to put on fat. The latter kind should be culled out in establishing a laying strain.
>
> More depends upon the breeding of the male as to the number of eggs the offspring will produce than upon the female, yet it will pay to breed from the best layers in preference to the poorest. Breeders should select the variety which suits them best as to color, size, and shape, and breed up until the fowls satisfy them as to quality and productiveness. They make a mistake by jumping from one breed to another, trying to discover a better layer. It will pay the average poultryman to trap nest his flock in fall and winter, and breed from the pullets which lay earliest in life and from the pullets and hens which lay in the winter. * * *

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[1] Compiled from Maine Sta. Bul. 192; New Jersey Stas. Bul. 244; New England Homestead, 65 (1912), No. 21, pp. 481, 485; Dept. Agr. N. S. Wales, Farmers' Bul. 57.

The best producers have broad bodies. The back is broad and the ribs are widespread, giving plenty of room for the egg organs and digestive organs. Their bodies are solid. The birds are not loose jointed, but compactly built. Good layers are big eaters. A bird must have capacity to eat and digest a great amount of food if she is to lay a great number of eggs.

A big decrease in the egg yield in winter can be brought on more quickly by great variations in temperature, sudden changes in weather conditions, than by continued or prolonged spells of either cold or rainy weather. It will pay to keep a good hen until she is 4 years old. We had several 4-year hens that laid over 150 eggs each. Most of the high producers have good-sized combs for birds of their variety.

In a contest conducted at the Connecticut Storrs station the highest individual average per hen was 214 eggs; in Missouri contest, 208 eggs. The average of all hens in the Missouri contest was 134.

A 10-year egg-laying contest with 360 hens of 60 different breeds closed in New South Wales in 1912. During that time there was a noticeable improvement of the type of bird, and the average number of eggs was raised from 131 to 184 per hen per year. The highest pen average exceeded that of either Connecticut or Missouri.

The results indicate the possibility of raising the average production, not only of breeders but of farm flocks, with little or no additional cost. To this end the poultryman should constantly try to build up his flock. This can best be done by selecting only the best females from the entire flock, by mating them to good vigorous males from high-laying mothers, and by using this special mating as a breeding pen from which all eggs for hatching should be saved. In this way a continual improvement will be had which can not be assured when the entire flock is used to propagate the future layers. In other words, as the New Jersey station points out—

the time has come for the poultryman to pay more attention to individual birds, and less to the flock as a whole, especially when breeding for future producers. The practice of making special breeding pens in this way is bound to result in time in larger, more vigorous birds, better layers, and hence more profit.

Great care should be exercised not to include in these special matings for breeding purposes any birds which have had any poultry disease. Some diseases, such as bacillary white diarrhea, * * * are known to be directly inherited, others are known to give to the offspring an inherited weakness which makes them especially susceptible to that particular disease. This is true of tuberculosis, diarrhea, enteritis, etc. Still others, such as roup, catarrh, and other general disorders, weaken the birds constitutionally and make them unfit for breeding. Any bird once affected with disease should be conspicuously marked, so that it may never find its way into the breeding pens.

In selecting the females for the breeding pen in the spring, the following factors have been found by observation and experimentation, to be essential to heavy egg production, namely:

(1) Breeding from heavy producers.

(2) The use of mature birds, preferably hens, not pullets.

(3) Line breeding rather than too close inbreeding or outcrossing.

(4) Breeding from birds which were early producers as pullets.

(5) Selecting birds which show a good vigorous constitution.

(6) Selecting for egg type (long, rather deep bodies with abundant room for the organs of digestion and reproduction).

(7) Selecting large specimens of the breed.

(8) Selecting late molters since they are usually the best winter layers.

(9) Breeding from birds which have shown by records to be persistent layers.

(10) Selecting birds that eat well, rise early, and retire late, for such birds are usually heavy layers.

The work of the Maine station indicates that in this breeding matings should be made only with the male progeny of high-laying mothers, because the high egg-producing power is transmitted through the male.

Without strong, well-bred birds a good egg yield is not certain, even with the most efficient management. Hence much time and thought and, if need be, money should be expended in the improvement of the flock by mating and breeding.

The birds set aside for breeding should be so cared for as to provide for the production of fertile eggs in the breeding season, which will hatch into vigorous chicks. They should not be crowded into small, insanitary houses, nor should they be forced for a heavy egg yield during the winter. The three factors which especially favor the production of fertile eggs are exercise, which can be made compulsory by supplying most of the feed in deep litter on the floor of the pen; green food, which for want of beets or cabbage can be supplied in the form of sprouted oats; and meat scrap, supplied liberally (15 per cent) during the breeding season, but not excessively prior to the breeding season.

The saving of eggs for hatching purposes should begin about the 1st of February. They should be collected at least twice a day, and should be kept at a temperature of about 45° to 50°. They should not be subjected to great variations in temperature, and should be placed so that they may be turned daily and protected from the direct rays of the sun. The factor of temperature is especially important, for the germ (embryo) begins to develop at 70° F. High temperatures start the development of the germ, but if heat is not supplied uniformly it ultimately dies. As a result of this, many eggs are later tested out as infertile. Eggs for hatching should be selected with a view toward uniformity in shape, size, and color, the idea being to select toward the ideal type of egg for the breed kept.

SPROUTING OATS FOR POULTRY.[1]

The feeding of green food to poultry in winter has been much practiced by experienced poultrymen. The chief function of such food is probably largely in the nature of a digestive stimulant rather than as an addition to the actual food constituents of the ration. In recent years sprouted oats have been very widely used as a green food for poultry. Experience at the Maine station indicates that in order to make a satisfactory product the oats must be grown very quickly and this requires plenty of warmth, moisture, and sunlight. Where the right combination of these factors can be gotten, oats may be satisfactorily sprouted for poultry feeding purposes.

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[1] Compiled from Maine Sta. Bul. 179.

At the Maine station use was made of a small room in connection with the station poultry plant. This room is provided with a 3-inch pipe connected with the water-heating system.

To provide a place in which to sprout oats, the back part of this room was partitioned off as a closet, inclosing the 3-inch hot-water pipe. The partition wall which forms the front of this closet consists of glass doors, made from regular storm-window sash, hinged so as to swing open as an ordinary door does. These glass doors face toward the south side of the building, which has a window directly in front of the doors. Throughout the day the closet gets plenty of light. The dimensions of this sprouting closet are as follows: Length, 9 feet 3 inches; depth, 2 feet 6 inches; height, 6 feet.

The place of shelves in this closet is taken by large, square greenhouse flats made of ⅞-inch stuff. These flats have the following dimensions: Length, 2 feet 5 inches (inside); breadth, 2 feet 5 inches (inside); depth, 2 inches (inside).

The length of the closet is such as just to accommodate three tiers of these flats, which slide on supports so that they can be moved in or out or turned around to suit the convenience of the operator and the needs of the sprouting grain. These flats set 15 inches apart (that is, vertically). There can be accommodated four rows of flats, three in a row, in the closet at one time. A number of holes are bored in the bottom of each one of the flats in order to drain off the surface moisture which comes with the wetting of the oats. * * *

The advantage of the closet arrangement described is that it enables one to control the three necessary factors of heat, moisture, and light quite completely. In this closet it is easily possible to maintain a temperature which does not run at any time below 70°. The closet being perfectly tight, it is possible to saturate the air with moisture quite easily and virtually convert the whole space into a great moist chamber. With this arrangement one is able to grow oats from 4 to 6 inches high in one week's time. The only difficulty with which one has to contend is the matter of mold. There is always a tendency for the oats to mold in the sprouting process. The only way in which it has been found possible to control this mold is by thoroughly cleaning the flats after each time when they are used. After a flat has been emptied it is thoroughly scrubbed with a 50 per cent solution of formalin (that is, equal parts of commercial formalin and water). This scrubbing is very thoroughly done and sufficient formalin is used to soak the flat thoroughly. With this precaution, and if the oats are further made to grow rapidly, the mold does not give any trouble whatever.

The actual method of sprouting the oats is as follows: Clean and sound oats are soaked in water overnight in a pail. The next morning flats are filled to the depth of about 2 inches and put into the sprouting closet. At the beginning freshly filled flats are placed near the top of the closet so as to get the maximum amount of heat, and in that way get the sprouts started at once. During the first few days, until the sprouts have become from a half to three-quarters of an inch long, the oats are thoroughly stirred and raked over at least two or three times during the day. This stirring insures an even distribution of moisture throughout the mass of oats in the flat. After the sprouts become sufficiently long so that the oats form a matted mass it is not desirable to stir them, or to disturb them in any way. Stirring at that time will break off and injure the sprouts and the green portion above the mass will not grow so well. The matter of prime importance in growing the oats successfully has been found to be sufficient moisture. The tendency at first is to use too little moisture. The oats should be kept quite wet. The aim here is to keep condensed moisture standing on the glass doors which form the front of the closet at all times. In order to do this it is found necessary to wet the oats three times a day. This is done with an ordinary greenhouse sprinkling can, with very little expenditure of time or labor. As the oats grow the flats are moved to different positions in the closet. The taller the green material gets the nearer the flats are moved toward the floor, because the growing grain then needs less heat. This procedure leaves the desirable places in the closet for the grain just beginning to sprout, where high temperature is needed.

The oats are fed when they are from 4 to 6 inches in height. They are fed at the rate of a piece of the matted oats and attached green stalks about 6 to 8 inches square for each 100 birds per day. In feeding, this 6 to 8 inch square piece is broken into smaller pieces and scattered over the pen, so as to insure that all the birds shall have an opportunity to get some. Fed at the rate indicated, this material has never caused any bowel trouble among the birds.

It should be clearly understood that the purpose for which green sprouted oats are fed is their tonic and stimulative influence on the digestive organs. They are not fed for the food value of the oats themselves. If one wishes merely to feed oats they can be most economically fed not sprouted. The point of sprouting is to furnish fresh, succulent, green food during the winter months.

CARBOLIC ACID FOR CONTAGIOUS ABORTION IN CATTLE.[1]

W. J. Taylor, of the Montana Experiment Station, says that "when once a herd becomes infected, there is perhaps no other disease which causes greater losses, either in dairy or beef stock, than does contagious abortion. It is indeed a very difficult problem to handle and it becomes especially so to those owners whose stables and shelters for cattle are not of the most modern construction and do not lend themselves to thorough methods of disinfection."

The Montana station has been studying methods of prevention for several years, and Dr. Taylor now reports that carbolic acid, either fed in solution or injected hypodermically, seems to be a specific against the disease. He found that cows as a rule will eat with apparent relish as much as 750 cubic centimeters of a 4 per cent solution of carbolic acid in feed daily. However, hypodermic injection as a treatment in an affected herd involves less labor than feeding. The method used with range cattle was to run them into a chute and inject 10 cubic centimeters of 4 per cent carbolic acid under the skin just behind the shoulder blade every two weeks. In cases of impending abortion carbolic acid can be injected in sufficient quantities to cause staggering gait and dilation of the pupil of the eye (when it should be withheld for from 10 to 15 hours and repeated) with no apparent unsatisfactory after effects. All males used for breeding purposes should also be treated, because the disease may be transmitted through the medium of the male unless proper precautions are observed.

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[1] Compiled from Montana Sta. Bul. 90.

For disinfecting the male the ordinary 2-quart fountain syringe obtainable at most drug stores makes an ideal apparatus. The longest straight rubber nozzle should be used. If this can not be secured, an inexpensive and efficient apparatus may be made from a funnel, a piece of rubber tubing, and a metal tube, as shown in figure 10. * * * The funnel should be large enough to hold at least a quart, the rubber tubing long enough to reach from the ventral side of the body to the back bone, and the metal nozzle about 4 inches long. A pinch cock is placed on the tubing near the nozzle.

The method of procedure is as follows: Secure the animal to be treated in such a manner that he can not step from side to side or kick the manipulator. The funnel may be secured in a bracket or held by an assistant at about the level of the back of the animal. Pour at least a quart of the disinfecting solution into the funnel. The pinch cock will prevent it from running out. The operator now inserts the nozzle into the sheath and grasps the prepuce firmly between the thumb and forefinger of the left hand tightly about the nozzle. Release the pinch cock and allow the fluid to run into the sheath. With gentle pressure from the outside, rub the liquid as far back into the sheath as possible. Allow it to remain several minutes and then relax the hand and let the fluid escape. This should be repeated at least once about 20 minutes to ½ hour before service is desired.

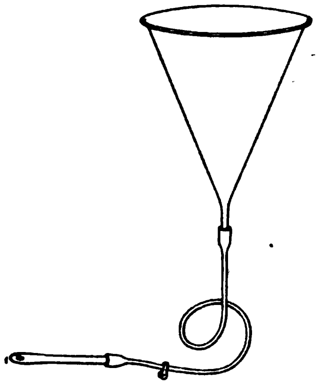

FIG. 10.—Apparatus for treating male animals infected with abortion.

In the experiment reported either a 1 per cent solution of carbolic acid (1 part of acid crystals in 100 parts of water) or a 1 to 2,000 solution of mercuric bichlorid containing 1 per cent of copper sulphate was used and proved efficient. The latter solution is made by dissolving 15 grains of mercuric bichlorid and 1¼ ounces of copper sulphate in 2 quarts of water.

Heifers pregnant for the first time are more liable to abort than during subsequent periods of gestation and should be carefully watched and vigorously treated if abortion exists in the herd.

COOLING CREAM WITHOUT ICE.[1]

In order to produce cream of high quality commanding a good price, it is necessary to cool it quickly after separation and to keep it cool until delivered. Warm cream should in no case be mixed with cool.

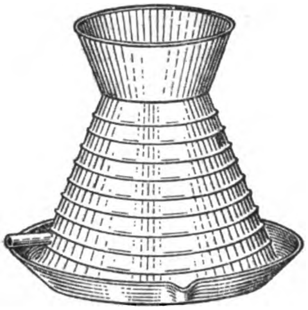

FIG. 11.—A small cooler for cooling cream as it comes from the separator.

J. H. Frandsen, of the Nebraska station, states that "a very simple and efficient way of cooling the cream quickly as it comes from the separator is by means of a small 'baby cooler' such as shown in figure 11. A cooler of this kind costs about $2.50 and may be used with running water, crushed ice, or cold well water."

A very efficient and satisfactory cooling tank used by the Nebraska station, and in modified form by many practical dairymen, is shown in figures 12 and 13. This tank should be not less than 18 inches wide and 26 inches deep.

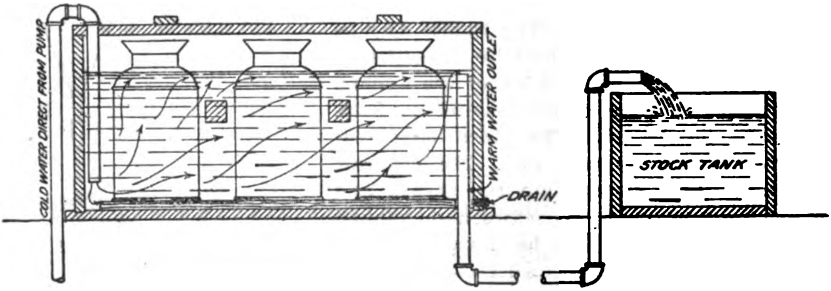

FIG. 12.—Tank for keeping cream cool while held at the farm.

The one shown in figures 12 and 13 measures 18 inches by 26 inches by 4 feet 9 inches. It is made of 1½-inch material and is fitted inside with a slatted bottom made of 1-inch strips. This slatted bottom is to allow the cold water to pass under as well as around the sides of the cans. The cold-water supply pipe is connected directly with the pump and discharges within about 5 inches of the bottom of the tank. At the opposite end is an overflow pipe to carry off the surplus water. This overflow is piped to the stock tank, so there is no unnecessary waste of water. The cool water directly from the well enters by the inlet pipe, and being discharged near the bottom it is distributed through the tank and displaces the warmer water which rises and is carried off by the overflow pipe. In this way the water is changed frequently and the cream kept quite cool. A tank as described may be built on the farm at a small cost. Where such a cooling system is used and other necessary precautions observed, it is possible to keep cream in good condition for several days, even in very warm weather.

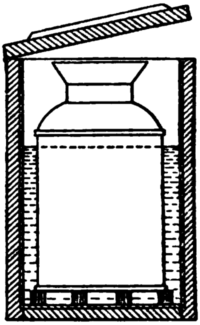

FIG. 13.—End view of the cream cooling tank.

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[1] Compiled from Nebraska Bul. 133.

The cream should be placed in the tank as soon as separated and then well stirred to bring it to the temperature of the water as quickly as possible.

It is well to remember that it is the cooling of the cream and not the mere fact of getting it into water that is so important. If the cream is stirred faithfully it will in a few minutes be reduced to the same temperature as the water in the tank, while if put into the tank without stirring it may remain warm for several hours. It is needless to say that just so long as the cream remains warm the bacteria, which even under the most sanitary conditions have gained access to the cream, will not be hindered in their growth. The vast majority of milk bacteria, however, grow very slowly at the temperature of ordinary cold water; hence the importance of cooling the cream very quickly.

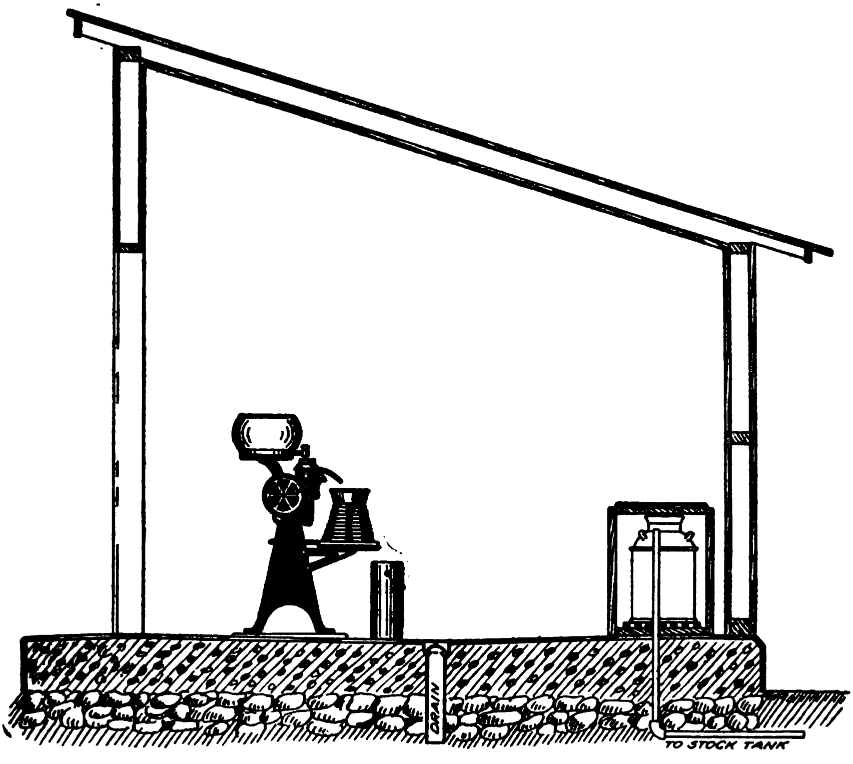

FIG. 14.—Convenient arrangement of separator, cooler, and cooling tank in a dairy house.

A convenient arrangement of separator, cooler, and cooling tank is shown in figure 14:

In those parts of the State where it is exceedingly difficult to secure a good supply of cold water, or in the newly settled sections where as yet not enough dairying is done to warrant the building of a milk house and cooling tanks, pits or shallow wells could be used for storing milk and cream, as shown in figure 15. Experiments indicate that these pits may have a temperature of less than 70° when the actual temperature in the shade was 104° F. When these special pits are used for no other purpose the milk and cream is usually of a much better quality than would be the case if it had been stored in the ordinary cave or root cellar containing vegetables of all sorts. It is a well-known fact that milk and cream readily absorb odors from anything that may stand near them.

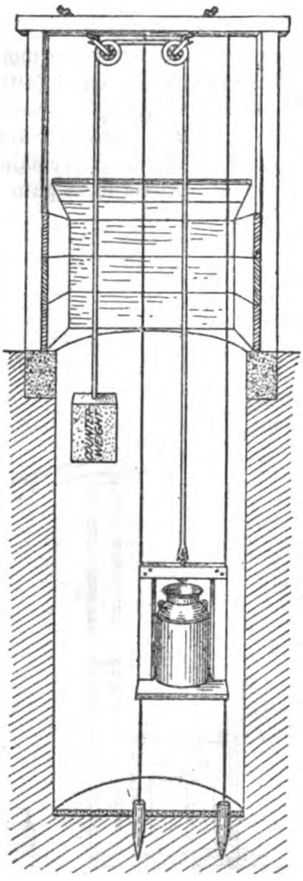

Fig. 15.—A pit or milk well for keeping cream cool.

A well or pit suitable for the cooling of the cream should be about 10 or 15 feet deep and can be cemented, bricked, or boarded up, as seems best under local conditions. It is not expensive and no particular skill is required to construct a pit of this kind. Figure 15 illustrates one of these pits and shows a simple hoisting apparatus with counterweight. The two guide wires running from the upper framework to the two stakes in the bottom of the well keep the elevator in place. The size of the elevator and of the counterweight depends, of course, upon the load to be carried and can be varied to meet the needs of practically all conditions.

Where ice is available, of course the problem of cooling is greatly simplified.

The cream should be delivered not less than three times a week during the summer. If the cream is hauled to the station early in the morning and the cans protected by covering with a wet sack while on the road to the creamery or station, the farmer will be enabled to deliver the cream at a much lower temperature than would otherwise be possible. During the wintertime the cream need not be delivered oftener than two or three times a week.

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Issued July 9, 1913.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 550.

CRIMSON CLOVER:

GROWING THE CROP.

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BY

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Agronomist in Charge of Clover Investigations, Office of Forage-Crop Investigations,
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WASHINGTON:
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1913.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., June 12, 1913.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin the accompanying manuscript entitled "Crimson Clover: Growing the Crop." This has been prepared by Mr. J. M. Westgate, Agronomist in Charge of Clover Investigations, and has been submitted by Prof. C. V. Piper, Agrostologist in Charge of Forage-Crop Investigations, with a view to publication. It is expected that this bulletin will be followed soon by other bulletins, each treating of some particular phase of this important crop.

Respectfully,

Wm. A. Taylor,
Chief of Bureau.

Hon. D. F. Houston,
Secretary of Agriculture.

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CRIMSON CLOVER: GROWING THE CROP.

INTRODUCTION.

Probably the most important characteristic of crimson clover is its ability to grow and make its crop during the season when the land is not occupied by the ordinary summer-grown crops. In sections where it succeeds, crimson clover can be sown following a grain crop or in an intertilled crop in late summer and will mature a hay crop the following spring in time to plow the land for spring-seeded crops, such as corn or cotton. It may even be held for seed as far north as central Delaware and the stubble be plowed under in time for seeding the quick-maturing strains of corn. It may be turned under for soil improvement when only 6 inches high if it is desired to fit the land for early spring-seeded crops. Even if only the stubble be turned under, the effect upon the succeeding crop will be marked, especially if the soil be deficient in nitrogenous fertilizers. The plowing under of the entire plant, however, will more rapidly correct any deficiency of nitrates or humus in the soil. It is one of the best cover crops for use in orchards and, in fact, under any conditions where the soil is likely to wash during the winter months. The many uses to which this crop may be put merit a careful study of the best methods of establishing a stand of crimson clover upon a farm.

HISTORY AND PRESENT DISTRIBUTION OF CRIMSON CLOVER.

Crimson clover (fig. 1) is frequently called "Scarlet clover" and, somewhat less commonly, "German clover," "Italian clover," "French clover," "Incarnate clover," "Annual clover," etc. It occurs wild in England and in eastern and southern Europe and is grown as a forage and soil-improving crop in Italy, France, Germany, Austria, and Great Britain. It was introduced into this country as early as 1822, but was grown only to a very limited extent until about 1880. It has proved especially adapted to the lighter, sandy soils of the eastern part of the United States where the winters are not too severe.

In the Middle Atlantic States it is also grown to a considerable extent on the clay soils of the Piedmont section.

In Michigan it is sometimes used on the sandy soils as a cover crop in peach orchards, although it frequently winterkills. It can not ordinarily survive the severe winters of the Northern States.[1]

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[1] In such northern sections where a fall-seeded legume is desired it is suggested that hairy vetch seeded with rye be used instead. See Farmers' Bulletin 515, entitled "Vetches."

Crimson clover is a "winter annual," that is, it ordinarily makes its early growth in the autumn, passes the winter in a somewhat dormant but green state, makes a very early spring growth, and matures its seed and dies before summer. It makes little or no growth in very hot weather and therefore should not be sown in the spring, except in the extreme North, where it may make a satisfactory growth by autumn, so that a hay crop may be taken from it at that time.

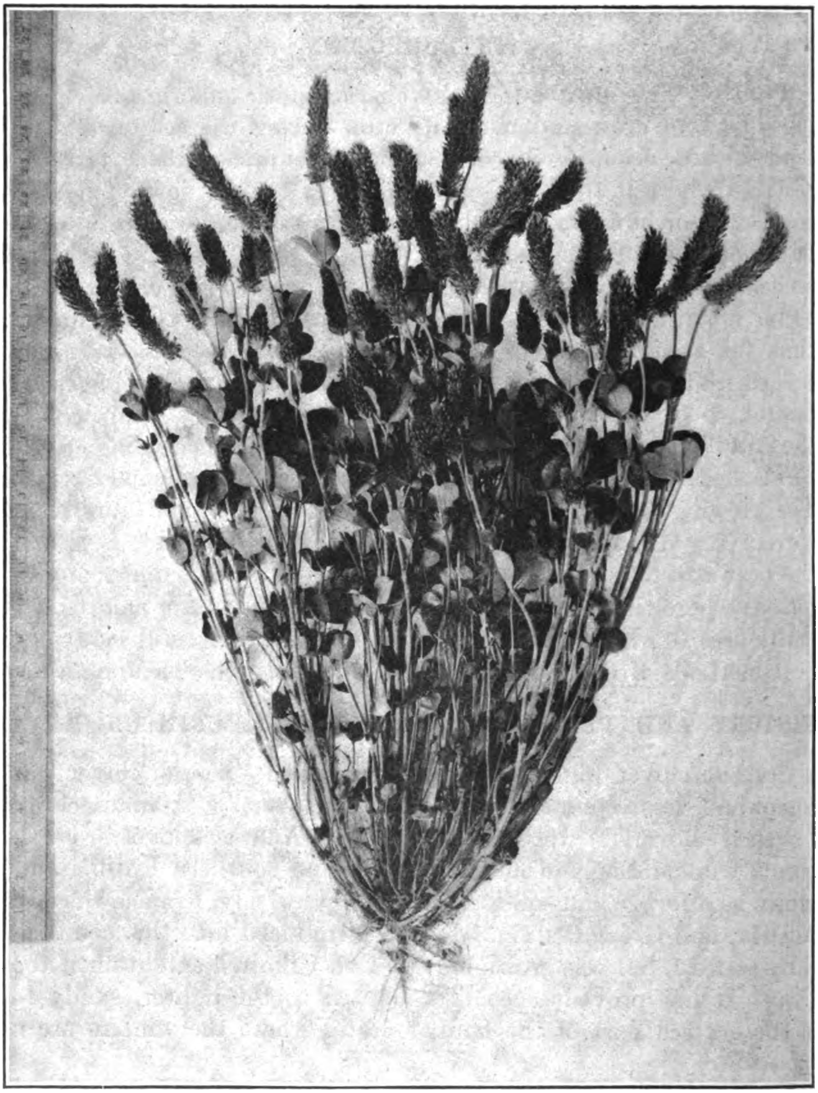

Fig. 1.—A single plant of crimson clover.

REQUIREMENTS FOR OBTAINING AND MAINTAINING A STAND OF CRIMSON CLOVER.

Unless the conditions of soil and moisture are exactly right it is not an easy matter to establish a satisfactory stand of crimson clover, even in the sections where it is most extensively produced. (Fig. 2.) The lack of timely rains in late summer is responsible for most of the failures to obtain a satisfactory stand. The young seedlings are very easily killed by the hot sun or lack of moisture. On the other hand, if the seeding be delayed too long, as, for instance, in waiting for the proper conditions of soil moisture, the plants will be unable to make sufficient growth to withstand the winter. Briefly speaking, crimson clover should be seeded shallow on a moist, reasonably fertile, well-drained, well-settled seed bed. Inoculation in some form should be provided, especially when seeding it for the first time on any fields in sections comparatively new to this crop.

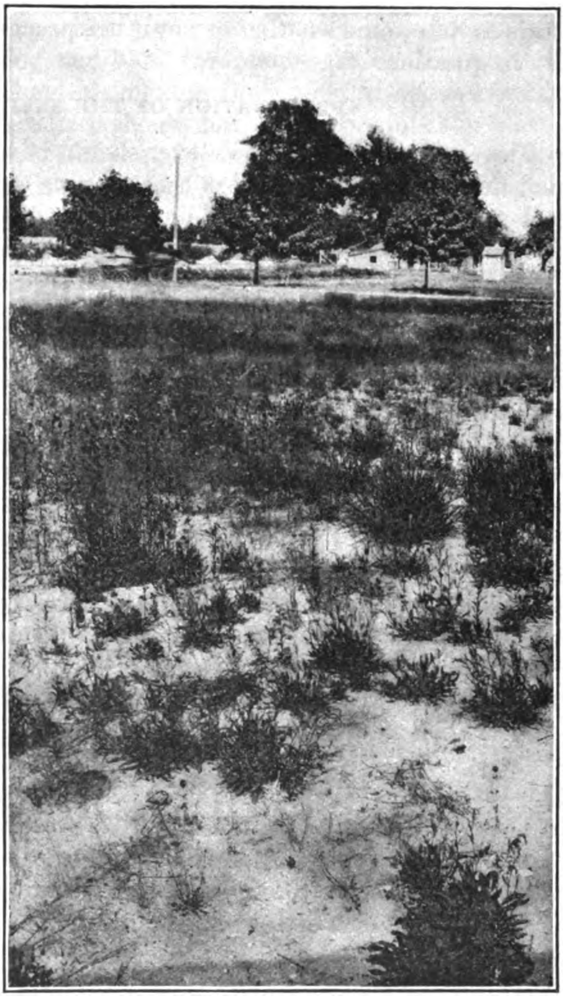

FIG. 2.—A crimson-clover failure on ground too poor in humus.

Crimson clover is not adapted to the white-clay lands in their present condition in some portions of the Atlantic Coastal Plain. Such fields should be seeded to soy beans or cowpeas when a leguminous crop is desired for soil improvement or other purposes.[1] Crimson clover does not do well on rough, newly cleared land and it ordinarily requires the production of two or three crops or a special preparation by liming, manuring, and inoculating before such land presents conditions satisfactory for seeding. It is usually better to sow rye for a winter cover and cowpeas for a summer crop if a cover crop is thought to be needed. In any section where crimson clover has not been previously grown the first seeding should be on a small scale to determine whether or not it is a practicable crop for the locality in question.

---

[1] These white-clay soils are nearly always sour, deficient in humus, and poorly drained. If limed, subsoiled, drained, and supplied with humus, such soils are said to grow crimson clover satisfactorily.

PREPARATION OF THE SEED BED.

The seed bed for crimson clover should be firm, moist, well settled, and fine on top. Any efforts that may be expended to conserve the soil moisture previous to seeding are usually justified, especially if there be any lack of rainfall during the month previous or the month following seeding. Where the clover is seeded in an intertilled crop, such as corn, cotton, or tomatoes, the customary cultivation received by these crops is ordinarily sufficient for the needs of crimson clover. Where grain-stubble land is plowed in preparation for the clover a month or six weeks are ordinarily required for the soil to settle sufficiently to make a proper seed bed, since after plowing at least one soaking rain, which compacts the soil and fills it with moisture, is essential to the proper preparation of the seed bed for crimson clover. If the ground be disked, a much shorter time and less rain are required for the proper settling of the seed bed. The best method of retaining the moisture in the seed bed is to harrow or give shallow cultivation shortly after each rain. A fine soil mulch on the surface will largely prevent the soil just beneath the surface from losing its moisture through evaporation. Such surface tillage should, of course, be given before seeding the crimson clover.

FERTILIZERS FOR CRIMSON CLOVER.

Under the ordinary conditions of soil fertility the fertilizer applied to the preceding crop is sufficient for the needs of crimson clover. This is especially true where the clover follows such crops as potatoes or tomatoes, which are ordinarily heavily treated with fertilizers that are not entirely used up by these crops. It is important to realize, however, that crimson clover has a very short period of growth and that to make a vigorous growth it must have a good supply of plant food. On sandy soils where there has been no recent application of fertilizers it is often the practice to apply from 200 to 400 pounds of a mixture of equal parts of acid phosphate and kainite. On clay soils 300 or 400 pounds per acre of acid phosphate are ordinarily sufficient. If the soil be low in nitrates a light application of nitrate of soda will assist materially in giving the young clover plants a good start and often enable them to withstand the effects of a late drought or severe winter which otherwise might have proved fatal to the stand. If the seeding has been delayed, as by waiting for suitable rains, an application of nitrate fertilizer will stimulate the young plants and enable them to make an increased growth before winter.

Any direct application of fertilizer is usually made at seeding time, but some few farmers have been found who apply it as a top dressing very early the following spring, giving as a reason that there is no loss from winter leaching and that the plants are by this method nourished at the time they are making their most vigorous growth. Such top dressings of fertilizer should not be made while the leaves are wet with rain or dew. Where stable manure is applied to crimson clover very marked results follow. It may be spread just before seeding, when the clover is not grown in an intertilled crop, or it may be applied as a top dressing in winter or very early spring.

The more vigorous the growth that can be induced by the application of suitable fertilizers the more marked will be the increase in the yield of the succeeding crops. On soil not well supplied with humus or plant food the use of a reasonable amount of fertilizer will often enable a successful crop of clover and succeeding crops to be produced where, had not the fertilizers been applied, the clover would have failed. Furthermore, the following crop, particularly if it be corn, would also fail to give the increased yield which follows a successful stand of crimson clover.

An application of barnyard manure will be found to be especially effective in obtaining a stand of crimson clover on any thin, galled spots in the field. The manure should be worked into the ground and, if possible, a second application as a top dressing should be given such thin places to partially shade the ground from the August sun while the seedlings are establishing themselves.

LIMING SOILS FOR CRIMSON CLOVER.

Most of the soils in the crimson-clover sections will be found to be benefited by liming. Crimson clover, however, does not appear to require lime to the extent that red clover does. Frequently on well-drained soils in a good state of fertility the crimson clover makes a vigorous growth without the use of lime. The stands are, however, usually more uniformly good over the limed parts of such fields than on the parts that have received no lime. The opinion among individual farmers appears to be about equally divided as to whether or not it pays them to lime their soils for crimson clover. In considering the advisability of applying lime one must not lose sight of the need of lime on the part of such other crops as cantaloupes or peaches, which require lime and which are either grown with the clover or follow it. Inasmuch as the extent of the benefit is somewhat uncertain it is suggested that the particular requirements of the farm in question be determined by liming small plats at different rates before any considerable areas are limed. The most profitable rate of application can then be adopted for the whole acreage.

INOCULATION FOR CRIMSON CLOVER.

Fortunately most of the soils in the crimson-clover sections appear to be already inoculated. This is especially true in sandy soil areas where crimson clover has been grown for a number of seasons. In sections new to this crop inoculation in some form is usually necessary. On clay soils inoculation is not always present, even though crimson clover may have been grown for a number of successive seasons on other fields of the farm.

An experiment conducted by the Alabama State Agricultural Experiment Station shows how essential inoculation is on soils which have not previously grown crimson clover. In this experiment a yield of 4,057 pounds of crimson clover hay was secured where the plants were inoculated, as compared with only 761 pounds where no inoculation was provided. In another test by the same station the inoculated plat of crimson clover yielded at the rate of 6,100 pounds of cured hay per acre, while the uninoculated plat was a total failure.

Inoculation by the use of soil from a crimson-clover field is considerably more certain than is inoculation by the use of pure cultures, but soil inoculation is open to the danger of introducing noxious weeds, insects, and plant diseases, especially if the soil is brought from a distance. There is much less danger in this respect if soil from inoculated plants can be obtained in the same neighborhood. One very practicable method is to apply a bottle of pure culture[1] to a pound or two of the seed and sow this in the corner of some field, or even in the garden. The resulting plants will be quite sure to be inoculated and will furnish an abundant supply of soil for inoculating much larger areas at the next seeding. Care must be taken not to allow the sun to shine upon either the pure cultures or the soil, or even on the seed after it is broadcasted. For this reason it is safest to seed on a cloudy day or after sundown. One very satisfactory method of soil inoculation consists merely in mixing together equal parts of the proper soil and seed and sowing immediately in front of the covering harrow.

SEEDING CRIMSON CLOVER.

Crimson clover may be sown broadcast, by hand, with a wheelbarrow "sheep-trough" seeder, or with any of the familiar types of rotary seeders. It is sometimes drilled in and there are a number of specially constructed drills designed for this purpose.

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[1] Pure cultures are sent free by the U. S. Department of Agriculture. Full instructions for using them accompany each bottle.

The consensus of opinion among farmers is that shallow seeding is generally best, especially upon the clay soils. An inch in sandy soils and half an inch in clay soils appears to be about the right depth except in times of drought.

The ordinary rate of seeding is 15 pounds per acre, although some use 20 pounds, while others are able to obtain satisfactory stands with only 12 pounds per acre. One pound of seed per acre provides for three seeds for every square foot; hence, if every seed produced a plant, 2 pounds per acre would be theoretically sufficient to secure a satisfactory stand. Under ordinary circumstances, however, it is necessary to allow for some of the seed being covered too deep, while a considerable proportion may prove to be covered too shallow for successful growth. The principal justification of seeding such a quantity and at varying depths lies in the fact that in case a dry season develops after seeding the more deeply covered seeds will be able to withstand the drought better than those covered to a medium depth. If an unusually wet season develops, the shallow-planted seeds will give the best results. Moreover, some of the seed will fail to germinate. It is also well to have a fairly thick stand of the young plants, so that the ground may be well covered even during early fall, and thus prevent the winter-growing weeds from establishing themselves.

It is held by many farmers that they are more certain of getting a stand of crimson clover if they sow the seed in the hull rather than use the hulled seed as it ordinarily appears on the market. It is claimed that the hulls hold the moisture to some extent. Seed in the hull can easily be obtained by flailing out a load of crimson clover which has been left uncut in the field until the seed is mature. Many farmers run the clover through an ordinary grain thrasher, which delivers the seed in the hull.

VARIOUS METHODS OF SEEDING CRIMSON CLOVER.

Crimson clover may be seeded in late summer in any of the ordinary intertilled crops. It may be seeded alone following any farm crop which can be removed from the land by early summer, so that the seed can be sown in late summer or very early fall. It may also be seeded for hay in mixture with grain, such as wheat, rye, barley, or winter oats, which are ready to cut for hay at about the same time as the clover the following spring. A very light seeding of an annual catch crop, such as buckwheat, may be made with crimson clover in time for the catch crop to make its growth before winter.

SEEDING CRIMSON CLOVER IN INTERTILLED CROPS.

Although crimson clover may be seeded in almost any of the intertilled crops, in this country probably half of it is sown in corn at or shortly after the time of the last cultivation. (Fig. 3.) It is usually possible to make such a seeding, obtain a good growth during the fall and early spring, and mature a crop of hay in time for breaking up the land for another crop of corn. South of the latitude of central Delaware it is even possible to mature a crop of clover seed in time for corn planting. In this way it is possible to grow a crop of corn each year and at the same time steadily increase the fertility of the soil for a series of years. Treated in this manner each succeeding crop of corn can ordinarily be materially increased. Instances are reported where the yield of corn has been gradually increased by this means from 10 bushels per acre at the start until as high as 70 bushels per acre were secured.

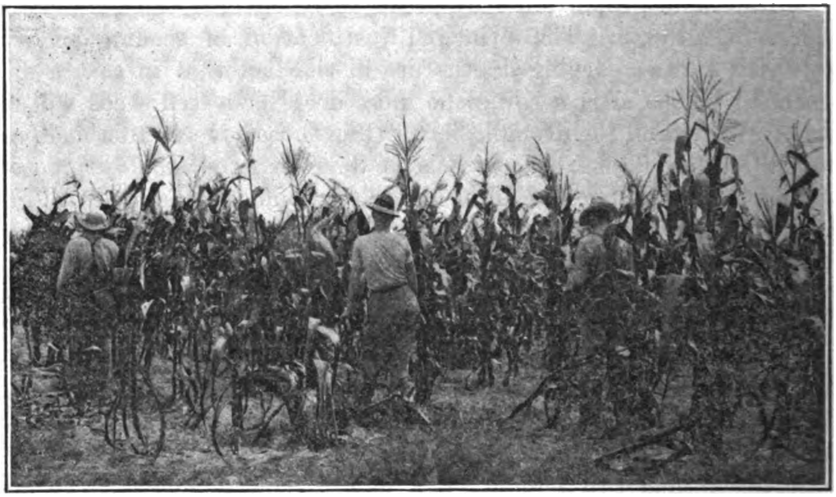

FIG. 3.—Seeding crimson clover in corn at the last cultivation.

The newly seeded stands of clover in corn are likely to perish if drought occurs at or after seeding time. The growing corn makes heavy demands on the soil moisture, and if there is not enough moisture for both clover and corn the latter gets the larger share and the tender clover plants are likely to succumb. It sometimes happens that a very light rain shortly after seeding the clover will cause the seeds to germinate, only to perish during the succeeding days of dry weather. On account of the competition for moisture between the corn and clover it is best to cover the clover seed a little deeper than is necessary when it is sown on fallow land.

North of the Potomac River the last cultivation of the corn comes at about the right time for the best results with clover seeded at the same time. Farther south, however, there is too much hot weather after the corn is laid by, and as a consequence it is best to delay the seeding of the crimson clover until about 8 or 10 weeks before the first frost may be expected. A light narrow-toothed cultivator or harrow may be run shallow between the rows to cover the seed. The seed may be sown broadcast by hand or even from horseback with a rotary seeder. In such an event, however, it is necessary to cover the ears of the horse with small bags or socks to prevent the entrance of the flying seed. A much more even stand is made possible if the corn is given level tillage rather than the ridged tillage incident to plowing with a 1-horse corn plow and ridging the land. The appearance of a field of crimson clover seeded the summer previous in corn is indicated in figure 4.

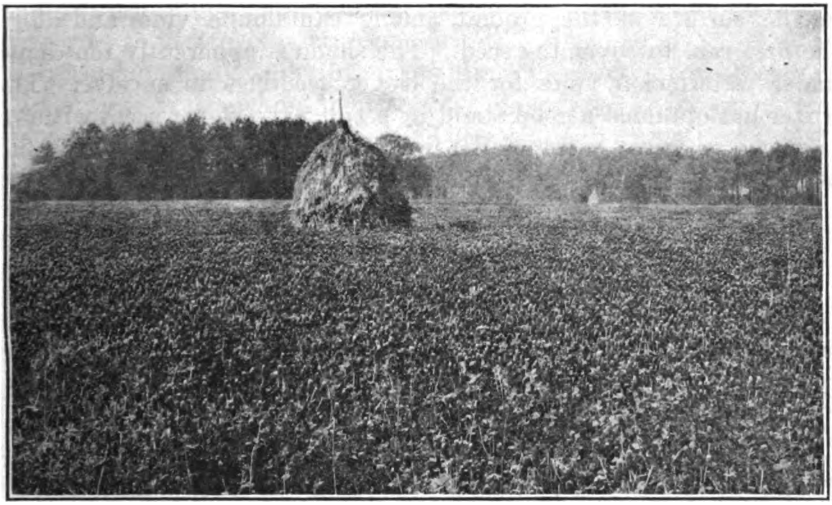

FIG. 4.—Crimson clover in an old cornfield. The clover was seeded in the corn at the last cultivation. A fodder stack is to be observed in the middle foreground. The cornstalks have been removed to avoid difficulty in mowing the clover.

In North Carolina and southern Virginia it has been found possible under favorable conditions to obtain a satisfactory stand of clover by seeding in cotton. The clover should not be sown until 10 or 12 weeks before frost and the last working of the cotton comes ordinarily at an earlier date than this. It is necessary that the cotton be given very clean culture, as well as special attention paid to conserving the moisture in the prospective clover-seed bed. Unless the first show of cotton is picked early it is difficult to cover the clover seed without unduly injuring the opened cotton bolls. In the higher and more northern parts of the cotton belt it is possible to make the clover seeding before the bolls begin to burst.

Crimson clover may be seeded in practically any of the cultivated truck crops which receive their last cultivation from 8 to 12 weeks before the first frost. It is not practicable to seed the clover in late potatoes, as the digging of the potatoes in the fall practically destroys the stand of clover. The heavy application of fertilizers necessary for the truck crops makes possible a vigorous growth of the clover. The result is that the soil is materially built up in both nitrogen and humus. The clover makes its growth at a season of the year when the land is not ordinarily occupied by any of the regular truck crops.

When timely rains follow the seeding it is possible to seed the clover on the surface of the ground among cantaloupe vines and allow the first rain to cover the seed. The shade is apparently too dense under watermelon vines for the clover seedlings to survive. The writer has obtained a good stand by seeding the clover seed, without covering, in sweet potatoes the first week in August on sandy land near Washington, D. C. By hand-digging the potatoes with a spade a fair stand of the clover plants was left unharmed.

SEEDING CRIMSON CLOVER AFTER EARLY-MATURING CROPS.

It is possible to seed crimson clover after practically any of the ordinary farm crops which can be removed from the land three months before frost.

It is somewhat difficult to obtain anything like an ideal seed bed for crimson clover where a field of grain stubble has been plowed under. The soil in a stubble field is apt to be dry and cloddy when plowed, while the stubble tends to form a dry mat at the bottom of each furrow. Such a condition is likely to continue for a number of weeks after plowing and to result disastrously to the clover seedlings unless there be abundant and frequent rains. It is ordinarily a better practice to disk the grain stubble and harrow every week, or at least after every rain, in order to settle the ground and assist in holding the moisture pending the time of seeding. Such frequent harrowings will also kill the successive crops of germinating weed seeds, which might otherwise injure the young stand of clover.

On the other hand, the ground from which early potatoes have been removed is very favorable for the establishment of a stand of crimson clover. The residual effect of the fertilizers used on the potatoes is partially responsible for this, while the well-settled seed bed, which requires only leveling and harrowing, also presents favorable conditions for the crimson-clover seedlings.

SEEDING CRIMSON CLOVER WITH LATE SUMMER-SEEDED ANNUAL CROPS.

Crimson clover may be seeded in midsummer or in late summer with a very light seeding of buckwheat. The buckwheat soon forms an ideal shade for the young clover plants and unless frosts occur very early a crop of buckwheat may usually be harvested. This method has been suggested as being applicable when seeding the clover in cotton. If the buckwheat is not seeded until August it will not ordinarily produce seed in the latitude of Washington, D. C. Wherever possible, the seeding of buckwheat and crimson clover should be made so early that there will be time for the buckwheat to mature its seed crop, as in this way the buckwheat itself will pay for the expense of starting both stands. A light seeding of the buckwheat must be made, as an ordinary stand of buckwheat shades the ground so completely as to destroy the crimson clover.

Another method of preventing the injurious effect of the hot sun of late summer is to make a light seeding of cowpeas at the same time that the crimson clover is seeded. The cowpeas germinate promptly, and being rather thin on the ground do not injure the stand of clover, but on the contrary afford sufficient shade to prevent the soil from becoming as hot as it otherwise would. In addition, the clover plants receive some protection from the direct rays of the sun. There is ordinarily not enough time for the cowpeas to mature, so they are either mown for hay or left standing to catch the snow during the winter and protect the stand of clover. In seedings made by the writer half a bushel of cowpeas per acre, broadcasted, gave very satisfactory results, the seeding being made August 1 on sandy ground near Washington, D. C. The clover and cowpeas were sown broadcast on early-potato ground and covered from one-half to 1 inch deep.

If a light seeding of turnips be made with the clover, the turnip plants will afford some protection to the young clover plants and at the same time will ordinarily yield a fair crop of turnips. About 1 pound of turnip seed and 15 pounds of clover seed should be sown to the acre. If the seeding of turnips be at all heavy the coarse-growing turnip plants will choke out too many of the clover plants. The Cow Horn turnips appear to be especially adapted for seeding with crimson clover.

CRIMSON CLOVER IN MIXTURES WITH OTHER LEGUMES AND GRAIN.

When crimson clover is seeded alone on good soil it is likely to make so rank a growth as to lodge. To overcome this difficulty it is a common practice to seed some small-grain crop with the clover at seeding time. South of the Potomac River winter oats are ordinarily very satisfactory, especially when seeded with the late white-blooming strain of crimson clover. In Delaware and eastern Maryland wheat is commonly used. In addition to wheat and oats, rye or barley is sometimes used. The customary rate of seeding is about 15 pounds of clover seed and 30 pounds of grain per acre. The accompanying illustration (fig. 5) indicates the appearance of a field seeded to a mixture of crimson clover and wheat. The grain prevents the clover from lodging, facilitates the curing of the clover hay, and, in addition, forms a valuable constituent of the resulting hay crop. The yield of the mixture is ordinarily somewhat more than when the clover is seeded alone. The Alabama State Agricultural Experiment Station secured as the average for two years' experiments the following yields of hay:

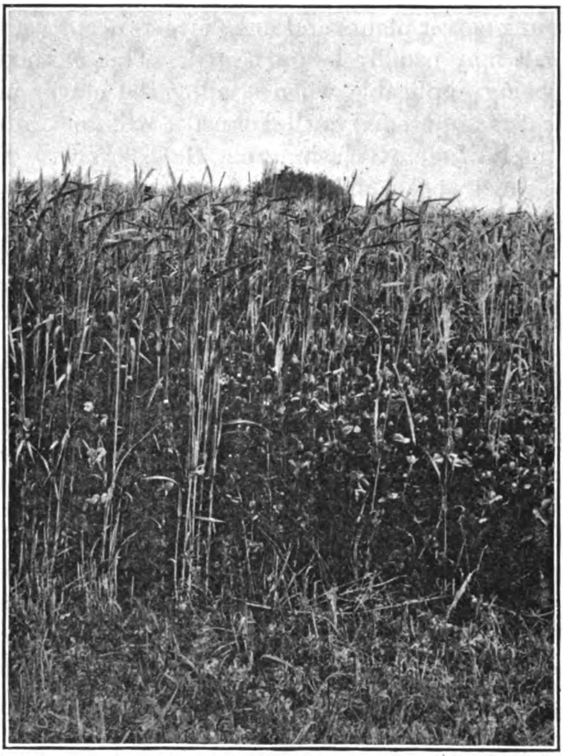

FIG. 5.—Crimson clover and wheat in mixture. In the foreground the crop has been cut and fed green to stock. The remainder was cut the next day for hay. The grain prevents the crimson clover from lodging.

	Yield per acre.
Crimson clover seeded alone	2,836 pounds.
Crimson clover seeded in mixtures:	
Barley and crimson clover	3.695 pounds.
Wheat and crimson clover	3,771 pounds.
Oats and crimson clover	4,228 pounds.

The grain is usually well headed but is in the milk or soft-dough stage when the clover is ready to cut. The presence of the grain hay makes the clover hay more easily cured. With winter oats it is usually best to seed the late white-blooming variety of crimson clover, as the oat crop matures somewhat later than the ordinary crimson clover. Another advantage of this mixture is that if either should fail the other will be present to serve as a cover crop during winter and bring some return the following spring.

Crimson clover may be seeded in mixtures with vetch, shaftal clover, trefoil, or, in fact, any winter-growing legume which has a growing season similar to crimson clover. Since most of these legumes are not upright in their growth it is usually necessary to seed some grain crop with them to serve as a support and to prevent the plants from lodging. The grain is ordinarily a surer crop than the legumes and practically insures the ground being covered with some crop during the winter and spring months.

SEEDING CRIMSON CLOVER ALONE.

If a good seed bed can be prepared by August 1 in the latitude of Washington, D. C., crimson clover will ordinarily produce a satisfactory stand if seeded entirely alone. This is especially true on the clay soils, where it is often difficult to obtain a successful catch in corn at the last working. The seed is sown at the same rate as when seeded in corn, namely, about 15 pounds per acre. It is the common practice to broadcast the seed and to cover with a very light harrow or weeder. Unless the August sun be unduly hot and a drought develops, such seeding will ordinarily produce very satisfactory results if the soil be reasonably fertile.

TREATMENT OF CRIMSON CLOVER STANDS AFTER SEEDING.

Ordinarily no special treatment is required after seeding, and before winter comes on some fall pasturage may be obtained if the growth be sufficiently rank. A light pasturing with sheep has been noted to induce heavier stooling on the part of the crimson clover. Only a light pasturing with small animals, such as sheep, calves, or chickens, should be made in either the fall or spring before the early spring growth is well under way. If the time of seeding has been delayed, or if for any reason it is feared that the plants will be unable to make sufficient growth before cold weather, it has been found that a top dressing of nitrate of soda alone or in mixture with muriate of potash will greatly hasten the fall growth. This reduces the danger from winterkilling and heaving out in the early spring.

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